NOAA Technical Report, OAR AOML-

BOYNTON INLET 48-HOUR SAMPLING INTENSIVES: JUNE AND SEPTEMBER 2007

T. Carsey
N. Amornthammarong
J. Bishop
F. Bloetscher
C. Brown
J. Craynock
S. Cummings
P. Dammann
J. Davis
C. Featherstone
C. Fischer
K. Goodwin
D. Meeroff
J. Proni
C. Sinigalliano
J. Stamates
P. Swart
J.-Z. Zhang

Atlantic Oceanographic and Meteorological Laboratory
Miami, Florida

January 2011

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Office of Oceanic and Atmospheric Research

NOAA Technical Report, OAR-AOML-

BOYNTON INLET 48-HOUR SAMPING INTENSIVES:
JUNE AND SEPTEMBER 2007

Thomas P. Carsey[1]
Natchanon Amornthammarong[2]
Joseph R. Bishop[1]
Frederick Bloetscher[3]
Cheryl J. Brown[2]
Jules F. Craynock[1]
Shailer R. Cummings[1]
W. Paul Dammann[1]
Jonathan Davis[2]
Charles M. Featherstone[1]
Charles J. Fischer[1]
Kelly D. Goodwin[4]
Daniel E. Meeroff [3]
John R. Proni[5]
Christopher D. Sinigalliano[1]
S. Jack Stamates[1]
Peter K. Swart[6]
Jia-Zhong Zhang[1]

[1]NOAA/Atlantic Oceanographic and Meteorological Laboratory/Ocean Chemistry Division
Miami, Florida

[2]University of Miami/Cooperative Institute for Marine and Atmospheric Studies
Miami, Florida

[3]Florida Atlantic University/Laboratories for Engineered Environmental Solutions
Boca Raton, Florida

[4]NOAA/Southwest Fisheries Science Center, La Jolla, California

[5]Florida International University/Applied Research Center, Miami, Florida

[6]University of Miami/Rosenstiel School of Marine and Atmospheric Science
Miami, Florida

January 2011

UNITED STATES DEPARTMENT OF COMMERCE

Mr. Gary Locke
Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Dr. Jane Lubchenco
Undersecretary for Oceans and Atmosphere/Administrator

Office of Oceanic and Atmospheric Research

Mr. Craig McLean
Acting Assistant Administrator

Disclaimer

NOAA does not approve, recommend, or endorse any proprietary product or material mentioned in this document. No reference shall be made to NOAA or to this document in any advertising or sales promotion which would indicate or imply that NOAA approves, recommends, or endorses any proprietary product or proprietary material herein or which has as its purpose any intent to cause directly or indirectly the advertised product to be used or purchased because of this document.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the funding agency.

Table of Contents

List of Figures

List of Tables

List of Acronyms

ADCP	Acoustic Doppler current profiler
AOML	Atlantic Oceanographic and Meteorological Laboratory
DIN	Dissolved inorganic nitrogen
DIP	Dissolved inorganic phosphorus
DOP	Dissolved organic phosphorus
FACE	Florida Area Coastal Environment program
FAU	Florida Atlantic University
FIB	Fecal indicator bacteria
MGD	Million gallons per day
NOAA	National Oceanic and Atmospheric Administration
POM	Particulate organic matter
qPCR	Quantitative polymerase chain reaction
TDP	Total dissolved phosphorus
TN	Total nitrogen
TOC	Total organic carbon
TON	Total organic nitrogen
TSS	Total suspended solids
RSMAS	Rosenstiel School of Marine and Atmospheric Science

Boynton Inlet 48-hour Sampling Intensives: June and September 2007

Abstract

Researchers with the Ocean Chemistry Division of NOAA's Atlantic Oceanographic and Meteorological Laboratory performed two 48-hour intensive studies of the water flowing through the Boynton Inlet at Boynton Beach, Florida, during June and September 2007. These studies were conducted in support of the Florida Area Coastal Environment (FACE) program. Academic partners who also participated in the effort included colleagues with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies and the Rosenstiel School of Marine and Atmospheric Science, Florida Atlantic University's Laboratories for Engineered Environmental Solutions, and the Applied Research Center of Florida International University.

Sampling was performed from the southern boardwalk at Boynton Beach during the June intensive and the Boynton Beach Inlet bridge during the September intensive. The sampling strategy was designed to collect water samples over four complete tidal cycles for each intensive; these data would be employed to quantify the total flux of nearshore-source entities into the coastal waters. The first sampling event was conducted on June 4-6, 2007, and the second was conducted on September 26-28, 2007. Data collected include nutrients (silicate, orthophosphate, ammonium, nitrite+nitrate), isotope ratios of nitrogen, the presence or absence of selected biological indicators (*Escherichia coli*, enterococci, and total coliform), and physical parameters that included pH, salinity, total suspended solids, and turbidity. Critical to this study was the continuous in situ flow rate measurements obtained via an acoustic Doppler current profiler (ADCP) mounted on the north side of the inlet.

This report presents the data gathered from the two sampling intensives. The data reported herein suggest that inlets are important contributors of nutrient and microbiological loads to the coastal zone. The overall view presented is that the lagoon input into Boynton Inlet may be substantial but is also highly variable.

1. Introduction

The Boynton Inlet (South Lake Worth Inlet) was created in 1917 to improve tidal circulation and provide flushing for the south end of Lake Worth Lagoon (PBCDERM, 1990). It is the southernmost outlet for the Lake Worth Lagoon, which itself receives input from three canals (C-16, C-17, and C-51), several cities, and non-point pollution sources which may include septic tanks, polluted aquifers, landfills, injected treated wastewater, and agricultural runoff. The inlet is approximately 200 feet wide and 12 feet deep (PBCDERM, 1990, reported a depth of 6 feet). Freshwater inflows to Lake Worth Lagoon are given in Table 1. The Lagoon is rapidly flushed by tidal action (mean tidal range at the Boynton Inlet is 2.5 feet); the estimated residence time to replace 50% of the lagoon water is one day (PBCDERM, 1990). The Lake Worth and Boynton Inlets are shown in Figure 1, along with the nearby South Central treated-wastewater plant ocean outfall.

Point source discharges into the Lake Worth Lagoon have been significantly reduced in recent years. Untreated wastewater discharge ended in the 1970s with the opening of several major wastewater treatment plants. Discharge from these plants amounted to ~3 million gallons per day (MGD) of secondarily-treated effluent in 1984. By 1990, the three wastewater treatment plants discharged a total of ~1.26 MGD of secondarily-treated wastewater effluent into the Lake Worth watershed (PBCDERM, 1990). A study of the nutrients in Lake Worth Lagoon (PBCDERM, 1990) concluded that the major pollution sources to the lagoon were the canal inflows.

Table 1: Freshwater inflows to the Lake Worth Lagoon[1]

Source	Percentage of Inflow
West Palm Beach Canal (C-51)	49.7
Earman River Canal (C-17)	12.5
Boynton Canal (C-16)	10.7
West Palm Beach sewage treatment plant[2]	1.3
Boynton Beach sewage treatment plant[2]	0.3
Groundwater	22.3

[1]Data from PBCDERM (1990).
[2]Sewage treatment plants which no longer discharge into the lagoon.

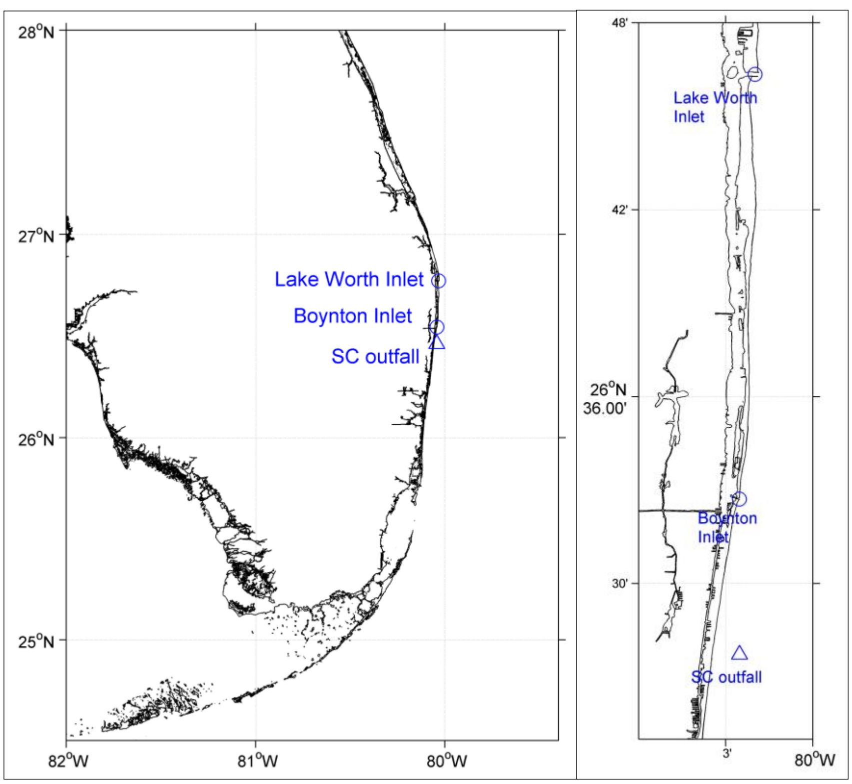

Figure 1. Location of the Boynton and Lake Worth Inlets, which drain the Lake Worth Lagoon, and the South Central treated-wastewater plant ocean outfall.

In 2006, NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) entered into an agreement with the Utility Council of the Florida Water Environment Association as part of the Florida Area Coastal Environment (FACE) program. The main purpose of the agreement was for NOAA to design a scientific study to investigate the principal sources of nutrients in the coastal waters of southeast Florida at selected locations. Scientific investigations pursuant to this agreement had indicated that Boynton Inlet was likely to be a significant source of anthropogenic material to the coastal ocean.

It was decided that a long-term investigation of the Boynton Inlet be conducted and that an intensive, 48-hour chemical and biological study of the water flowing through the inlet be performed to understand the impact of the inlet on the coastal ocean. The first 48-hour intensive was conducted on June 4-6, 2007; a second sampling intensive was conducted on September 26-28, 2007 due to deficiencies found in the first intensive. Additionally, the second intensive presented an opportunity to determine the consistency of the measurements gathered during the two intensives.

Because the flow at Boynton Inlet is principally tidally driven, there are two outflow/inflow cycles through the inlet each day. The 48-hour time period provided four outgoing and four incoming flows for investigation in each intensive. Between each pulse is a short time (~10 minutes) of nearly zero flow. A photograph of Boynton Inlet and the automobile bridge over the inlet are shown in Figure 2.

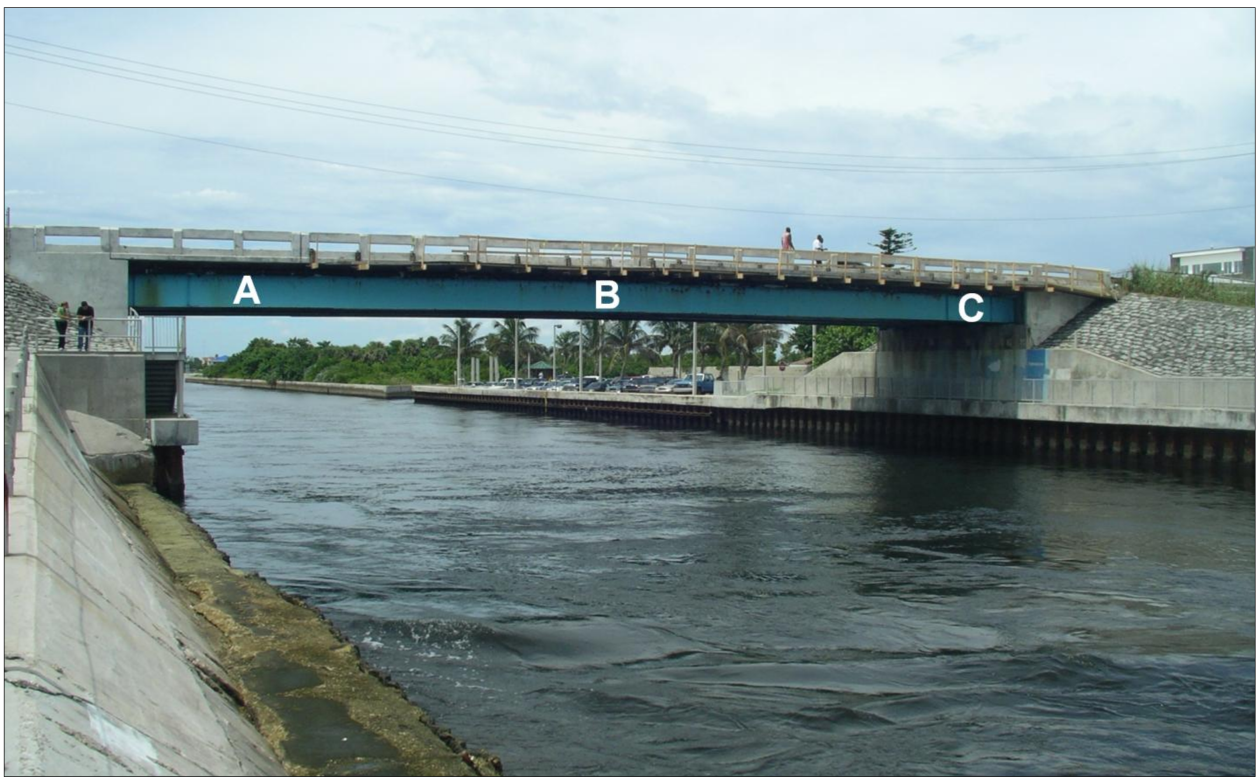

Figure 2. The Boynton Inlet bridge showing the three locations for water sampling during the September 2007 intensive (A = north end, B = center, and C = south end). A sample was collected from position B every hour on the incoming tide and every half hour on the outgoing tide. A sample was collected from all three positions (A, B, and C) once during an outgoing tide to measure variability in the nutrient concentrations across the channel.

2. Field Sample Collection Methods

2.1 Water Sampling

For the June 2007 intensive, sampling began at the center of the Boynton Inlet Bridge (location B, see Figure 2). Due to instrument difficulties, however, samples were instead collected from the south walkway near the overpass. For the September 2007 intensive, a sample was collected from location B every hour on the incoming tide and every half hour on the outgoing tide. A sample was collected from all three locations (A = north side of bridge, B = center of bridge, and C = south side of bridge) once during an outgoing tide to measure variability in the nutrient concentrations across the channel.

Three acid-cleaned, 15-L buckets were used to collect water samples from the Boynton Inlet. A single bucket was lowered by rope from the center of the bridge and rinsed three times with sample water before the final sample was collected. The bucket of sample water was transferred into the appropriate sample bottles and bags for subsequent analysis. The sample water was analyzed for $\delta^{15}N$ isotopes, nutrients (phosphorus [P], silicate [Si], nitrite [NO_2], nitrate [NO_3], ammonium [NH_4]), total nitrogen (TN), total organic nitrogen (TON), total organic carbon (TOC), total suspended solids (TSS), and microbiology. After the first hour of the outgoing tide, three samples were collected from the bridge at the A, B, and C locations to sample the possible variations in the parameters across the channel (Figure 1). A set of duplicate samples and a blank sample were also collected on the outgoing tide. Because of some contamination issues, orthophosphate results from the June intensive were not used in this report.

Water samples were filtered through 0.45 µm membrane filters using a 50 ml syringe and collected in two 8 ml polystyrene test tubes, one for ammonia-N analysis and the other for analysis of nitrate + nitrite-N, nitrite-N, silicate, and phosphate. Each filter was pre-washed, passing 50 ml of sample water through the filter before taking the final sample. Care was taken to avoid contamination of the nutrient samples, especially at low concentrations. Samples were stored in 8 ml polystyrene test tubes for analysis. Sample tubes were rinsed three times with sample water, shaking with the cap in place during each rinse. Nutrient sample tubes were filled with sample water and frozen prior to analysis. Ammonia samples were preserved by the addition of 0.2% (V/V) of chloroform, capped firmly, and stored on ice until transported back to AOML for analysis. This same procedure was performed during the September 2007 sampling period; however, the ammonia samples were collected and stored in 60 ml polystyrene test tubes.

Water samples for TSS analysis were collected in pre-cleaned 1-L bottles.

Water samples for $\delta^{15}N$ isotope analysis were collected during the September 2007 sampling period. Inlet water was collected in pre-cleaned, 250 ml bottles filtered through GF/C 25 mm filters, acidified to a pH of 2-3 with 10% hydrochloric acid (HCl), and stored frozen.

Water samples for microbiological analysis were collected in sterile Whirl-Pak® bags and stored on ice. Microbiological samples were processed within 6 hours of their collection.

In the field, general water quality data (pH, conductivity, salinity, water temperature, and dissolved oxygen) were collected using a YSI 556 multi-parameter probe (YSI Inc., Yellow Springs, OH), which was calibrated daily. For pH, a three-point calibration was performed with YSI pH standard solutions of 4.0, 7.0, and 10.0. For conductivity, specific conductance, total dissolved solids, and salinity, a YSI standard solution of 10,000 mS/cm was used. For dissolved oxygen, a water-saturated air calibration method was used, as follows: 3 mm (1/8 inch) of water was placed in the bottom of the calibration cup. After 10 minutes, the air in the calibration cup was considered water-saturated, and the dissolved oxygen was calibrated to 100%.

Additional observations that were recorded included general weather conditions, ambient air temperature, tidal conditions, previous rainfall, approximate channel depth, and current direction and strength. This information was collected using a Kestrel K3000 hand-held weather station (Nielsen-Kellerman, Boothwyn, PA) and through visual observations.

2.2 Flow Measurements

To estimate the volume of water passing through the Boynton Inlet, a Sontek 500-kHz side-looking Doppler sonar was installed on the north side of the inlet on February 20, 2007. This system estimated the volume of water flowing through the Boynton Inlet at 15-minute intervals. This was accomplished by making simultaneous measurements of the water level at the location of the instrument and the flow velocity in a measurement cell encompassing approximately the middle 50% of the channel at the location of the instrument. This cell was chosen so that the velocity measured best represented the mean channel velocity in the inlet. The water level measurement, in conjunction with knowledge of the channel geometry, provided an estimate of the cross sectional area of the channel. The product of the channel cross sectional area estimate (m^2) and the estimate of the mean channel velocity measurement (m/sec) provided the flux of water passing through the channel at that time (m^3 sec^{-1}).

To correct for the particular characteristics of this inlet, a series of calibration exercises was carried out using a 1200-kHz RD down-looking Doppler sonar instrument. This instrument was transected across the inlet multiple times during the tidal cycle (flood and ebb). During these transects, data were gathered across the entire width of the inlet. Data from these calibration exercises enabled the correction of the velocity measurements made by the side-looking Doppler sonar to more closely represent the true mean channel velocity of the inlet.

3. Analytical Methods

3.1 Particulates

3.1.1 Total Suspended Solids

Samples were measured for total suspended solids at Florida Atlantic University's Laboratories for Engineered Environmental Solutions. These samples used 4.25 cm Whatman® 934-AH glass fiber filter disks (catalog number 1927-042) with a nominal pore size of 1.0 µm. The filtration apparatus consisted of three plastic Millipore® 47-mm diameter filter holders with plastic filter support screens, 300 mL magnetic seal filter funnels, and a 4000 mL vacuum filtering flask. Each filter setup was attached to a vacuum filtration manifold using silicone vacuum tubing. A Gast® dry-air vacuum pressure pump with a maximum applied pressure of 15 psi was used. Each filter was pre-rinsed with three aliquots of reagent-grade water. Approximately 1000 mL of sample was filtered in each test, and the container and graduate cylinder used for transfer were both washed with three aliquots of reagent water to ensure complete transfer of the sample to the filter. Filtered samples were dried at 105°C on pre-labeled aluminum weighing dishes using a Precision Scientific® variable temperature control drying oven. All samples were weighed by difference on a Mettler® AC 100 calibrated top-loading balance. The detection limit was 0.1 mg/L. Finished samples were sealed in a plastic bag and delivered to AOML for further analysis of suspended nutrient content.

3.1.2 Turbidity

A portable nephelometer (VWR Model 800 turbidity meter) was used to measure turbidity. Cuvettes were rinsed with reagent water thoroughly before each use and pre-rinsed with three aliquots of sample.

3.2 Dissolved Nutrients and Organics

Nutrient analysis was conducted using the following methods of the Environmental Protection Agency (EPA).

3.2.1 Ammonia (NH_4)

EPA method 349.0 was used to determine the concentration of ammonia for each station (Zhang *et al.*, 1997a). This method uses automated gas segmented continuous flow colorimetry for the analysis of ammonia. Ammonia in solution reacts with alkaline phenol and NaDTT at 60°C to form indophenol blue in the presence of sodium nitroferricyanide as a catalyst. The absorbance of indophenol blue at 640 nm is linearly proportional to the concentration of ammonia in the sample.

3.2.2 Nitrate + Nitrite (N + N)

EPA method 353.4 was used to determine the concentration of nitrate and nitrite for each station (Zhang *et al.*, 1997b). This method uses automated gas segmented continuous flow colorimetry for the analysis of nitrate and nitrite. Samples were passed through a copper-coated cadmium reduction column. Nitrate is reduced to nitrite in a buffer solution. The nitrite is then determined by diazotizing with sulfanilamide and coupling with N-1-naphthylethylenediamine dihydrochloride to form a color azo dye. The absorbance measured at 540 nm is linearly proportional to the concentration of nitrite + nitrate in the sample. Nitrate concentrations were obtained by subtracting nitrite values, which were separately determined without the cadmium reduction procedure from the nitrite + nitrate values.

3.2.3 Silicate (Si)

EPA method 366.0 was used to determine the concentration of silicate for each station (Zhang and Berberian, 1997). This method uses automated gas segmented continuous flow colorimetry for the analysis of dissolved silicate concentration. Silicate contained in the sample reacts with molybdate in acidic solution to form β-molybdosilicic acid. The β-molybdosilicic acid is then reduced by ascorbic acid to form molybdenum blue. The absorbance of the molybdenum blue, measured at 660 nm, is linearly proportional to the concentration of silicate in the samples.

3.2.4 Orthophosphate (P)

EPA method 365.5 was used to determine the concentration of orthophosphate for each station (Zimmermann and Keefe, 1997; Zhang *et al.,* 2001). This method uses automated colorimetric and continuous flow analysis for the determination of low-level orthophosphate concentrations. Ammonium molybdate and antimony potassium tartrate react in an acidic medium with dilute solutions of phosphate to form an antimony-phosphomolybdate complex. This complex is reduced to an intensely blue-colored complex by ascorbic acid. The absorbance measured at 800 nm is proportional to the phosphate concentration in the sample.

3.2.5 Total Dissolved Phosphorus (TDP)

EPA method 367.0 was used to determine the total dissolved phosphorus concentration for each station (Zhang *et al.*, 1998). This method determines the total dissolved phosphorus concentration by autoclave promoted persulfate oxidation of organically-bound phosphorus, followed by a gas segmented continuous flow colorimetric analysis of digested samples. In this method, dissolved organic phosphorus (DOP) in the water reacts with persulfate in acidic media at an elevated temperature and pressure. An autoclave is used to achieve a temperature of 120°C and pressure of 2 atmospheres, which promotes oxidation. After samples are cooled to room temperature, an aliquot of ascorbic acid is added to remove the free chlorine formed in seawater during the digestion. These autoclaved samples are then analyzed for phosphate concentrations by the molybdenum blue colorimetric method using a gas segmented continuous flow analysis by a flow solution analyzer. In this method, phosphate reacts with molybdenum (VI) and antimony in an acidic medium to form an antimonyphosphomolybdate complex. This complex is subsequently reduced by ascorbic acid to form a blue complex and the absorbance measured at 710 nm. Undigested samples were analyzed separately to obtain the concentration of dissolved inorganic phosphate (DIP). Dissolved organic phosphorus was calculated as the difference between total dissolved phosphorus and dissolved inorganic phosphorus (DOP = TDP – DIP).

3.2.6 Total Nitrogen (TN)

Total nitrogen was measured using the thermal decomposition/NO detection chemi-luminescence method in a Teledyne/Tekmar Apollo 9000 total organic carbon analyzer with total nitrogen module. When a sample is introduced into the combustion tube (furnace temperature 720°C), the TN in the sample decomposes to nitrogen monoxide. However, nitrogen gas does not become nitrogen monoxide under these circumstances. The carrier gas (pure oxygen), which contains the nitrogen monoxide, is cooled and dehumidified by the electronic dehumidifier. The gas then enters a chemiluminescence gas analyzer where the nitrogen monoxide is detected. The detection signal from the chemiluminescence gas analyzer generates a peak, and the TN concentration in the sample is measured against a five-point standard curve.

3.2.7 Total Organic Carbon (TOC)

Total organic carbon samples were placed in a pre-cleaned 40 ml glass vial and then placed in the auto-sampler of the Teledyne/Tekmar Apollo 9000 total organic carbon analyzer. This method determines the organic content of a sample after the removal of inorganic carbon. Samples were acidified to a pH of 2-3, and carbon dioxide derived from inorganic carbon in the sample was removed by purging. The remaining organic carbon in the sample was introduced into a combustion tube filled with a platinum oxidation catalyst and heated to 680°C. The sample is oxidized in the combustion tube, and the contents converted to carbon dioxide. Carrier gas, which flows at a rate of 150 mL/min to the combustion tube, carries the sample combustion products from the combustion tube to an electronic dehumidifier where the gas is cooled and dehydrated. The gas then carries the sample combustion products through a halogen scrubber to remove chlorine and other halogens. Finally, the carrier gas delivers the sample to the detector where it is measured against a five-point standard curve to determine the total organic carbon content.

3.2.8 Particulate Organic Matter (POM)

Particulate organic matter filters were freeze dried prior to analysis. The area of the filter containing filtrate was removed, split in half, and placed in 5 × 3.5 mm tin capsules for dual analysis of $\delta^{15}N$ and $\delta^{13}C$ on a Europa Scientific ANCA GSL prep device interfaced with a 20/20 continuous flow stable isotope ratio mass spectrometer.

3.2.9 pH

Analysis of pH was performed with a WPI spectrophotometer using a 1 cm cuvette cell, usually within hours of sample collection. All samples were brought to room temperature prior to analysis. Samples were collected in clean, 20 ml polypropylene vials. Prior to analysis, 30 µL of m-creosol was added to approximately 10 ml of sample and then agitated. The sample was then placed in a 1 cm cell, and peak absorbencies were recorded at 434 nm, 578 nm, and 725 nm. Absorbance and salinity data were used to compute pH.

3.3 Nitrogen Isotopes

Ammonium is quantitatively converted to NO_2^- by the addition of hypobromite (BrO^-) under basic conditions. The NO_2^- produced is reduced to N_2O with a 1:1 azide and 100% acetic acid buffer solution. The N_2O produced is then analyzed on an automated continuous flow purge and trap system interfaced with a GV IsoPrime stable isotope mass spectrometer for $\delta^{15}N$. Samples with greater than 0.1 µM NO_2^- were excluded from analysis due to $\delta^{15}N$ contributions from NO_2^-, and samples with less than 0.5 µM NH_4^+ were excluded due to machine limitations.

3.4 Microbiology

3.4.1 Viable Bacterial Indicators

Viable bacterial indicators were enumerated by the EPA-approved Chromogenic Substrate Most Probable Number Method. Sample processing and analysis followed the procedures outlined in the *Standard Methods for the Examination of Water and Wastewater* (APHA-AWWA-WEF, 1995). Bacteriological samples were analyzed within 6 hours of collection by FAU's Laboratories for Engineered Environmental Solutions using the chromogenic substrate technique (IDEXX Colilert™ test) for total coliform and *E. coli* (SM9223B) and the IDEXX Enterolert™ test for enterococci (SM9230C). All samples were diluted to 1:10 with sterilized reagent water to reduce the ionic strength of the marine water matrix. Field duplicates and laboratory replicates were analyzed for approximately 10% of the samples.

3.4.2 Protozoan Cysts

Protozoan cysts were eluted from FiltaMax™ filter cartridges (IDEXX) with an automated FiltaMax Wash Station using a 1X PBST buffer according to the manufacturer's instructions. Enumeration of protozoan *Cryptosporidium* oocysts and *Giardia* cysts in the eluate was conducted by immunomagnetic separation and immunofluorescent microscopy according to EPA Standard Method 1623 (EPA, 2005).

3.4.3 Total Community Bacterial Populations

Total community bacterial populations were harvested from water samples by the filtration of 1 L water samples onto cellulose nitrate membrane filters (0.45 µm pore size), followed by extraction of total genomic DNA from the filters using a FastPrep™ DNA Spin Kit (MP Biomedicals/Qbiogene) according to the manufacturer's instructions. Purified DNA from the samples was stored frozen for later analysis of specific bacterial fecal indicators and pathogens by real-time quantitative polymerase chain reaction (qPCR) as in section 3.4.5.

3.4.4 Viruses

Viruses were harvested from water samples by charge affinity through the filtration of 1 L water samples onto charged HA-type membrane filters (0.45-µm pore size). Viral RNA was extracted directly from the filters by bead beating in a Fast Prep instrument with a lysis buffer and purified from the lysate using a VirAmp RNA kit (Qiagen). Purified viral RNA was stored frozen for later analysis of specific viral fecal indicators and pathogens by real-time quantitative reverse-transcription PCR (qRT-PCR) as described in section 3.4.6.

Cycling conditions for all source-tracking qPCR assays were run on a MJ Research Chromo4 instrument in 25-µL reaction volumes using a QuantiTect Probe Mastermix kit (Qiagen) with 0.125-µL of each primer per reaction (from 100 µM stock) and 0.1 µL of probe per reaction (from 100-µM stock). Samples were run in triplicate wells (with one well spiked with inhibition control) with the following cycling parameters: 15 min denaturation at 95°C, followed by 45 cycles of 95°C for 15 sec, and 60°C for 1 min with a fluorescent plate read at the end of each extension.

3.4.5 Methods for Quantitative PCR Procedures

General enterococci 23S rRNA gene:

- Forward primer: 5'-AGAAATTCCAAACGAACTTG-3'
- Reverse primer: 5'-CAGTGCTCTACCTCCATCATT-3"
- Probe: 5'-6FAM-TGGTTCTCTCCGAAATAGCTTTAGGGCTA-BHQ-3'

Total *Lactococcus lactis* Control 16S rRNA gene:

- Forward primer: 5'-GCTGAAGGTTGGTACTTGTA-3'
- Reverse primer: 5'-TCAGGTCGGCTATGTATCAT-3'
- Probe: 5'-6FAM-TGGATGAGCAGCGAACGGGTGA-BHQ-3'

Human-source *Bacteroides* HF8 gene cluster marker:

- Forward primer: 5'-ATCATGAGTTCACATGTCCG-3'
- Reverse primer: 5'-CAATCGGAGTTCTTCGTG-3'
- Probe: 5'-6FAM-TCCGGTAGACGATGGGGATGCGTT-BHQ-3'

Human-source *Bacteroides* HuBac marker:

- As per Layton *et al.* (2006)
- Norovirus and enterovirus qPCR kits by Cepheid, Inc., as per manufacturer's instructions (with some modifications)

3.4.6 Methods for Non-Quantitative PCR Procedures

Human-source enterococci esp gene:

- As per Scott *et al.* (2005)

Campylobacter jejuni hipO gene:

- As per LaGier *et al.* (2004)

Salmonella spp. IpaB gene:

- As per Kong *et al.* (2002)

Pathogenic *E. coli* strain O157:H7 rfb gene:

- As per Maurer *et al.* (1999)

Staphylococcus aureus clfA gene:

- As per Mason *et al.* (2001)

Human adenovirus hexon gene:

- As per He and Jiang (2005). Additional analysis of viruses conducted by Dr. Jill Stewart of the Oceans and Human Health Center at Hollings Marine Laboratory.

3.4.7 Standards and Controls for Quantitative PCR

Quantitation standards for total *Bacteroides* and human source *Bacteroides* use purified genomic DNA from the culture *Bacteroides dorei*, measured by fluorescence with a Qubit fluorometer using the Molecular Probes® Quant-iT™ kit for dsDNA. Quantitation units for these qPCR assays were in genome equivalents (which can then be expressed as relative cell numbers with some assumptions/caveats about the average target copy number in the environmental population of target cells). Quantitation standards for total and human-specific *esp*-containing enterococci were based on purified genomic DNA from a culture of *Enterococcus faecium* that contained the *esp* marker (acquired from Dr. Troy Scott at BSC Laboratories). Quantitation units for these qPCR assays were in genome equivalents.

Extraction controls: As indicated above, each sample was spiked before lysis and extraction with 10^5 cells of an enumerated control culture of *Lactococcus lactis*. Variations in the threshold cycle (CT) value of *Lactococcus* indicated variations of extraction efficiency plus any potential inhibition. Variations due to inhibition were removed by comparing extraction controls to inhibition controls.

Inhibition controls: Reactions for each sample were run in triplicate, and one replicate well of each sample was spiked with a known amount of target DNA. Variations in CT for spikes were corrected for background of unspiked for that sample, and indicate the degree of inhibition.

4. Data Summary and Discussion

4.1 Flow Characteristics

The two intensives were scheduled at very different times in the tidally-driven flow (Figure 3). The September intensive took place near the time of the perigean spring tide (new moon was September 26 [day 269], lunar perigee was September 28), while the June intensive occurred during more normal tidal flow. The September flow maxima were ~56% greater than those from June.

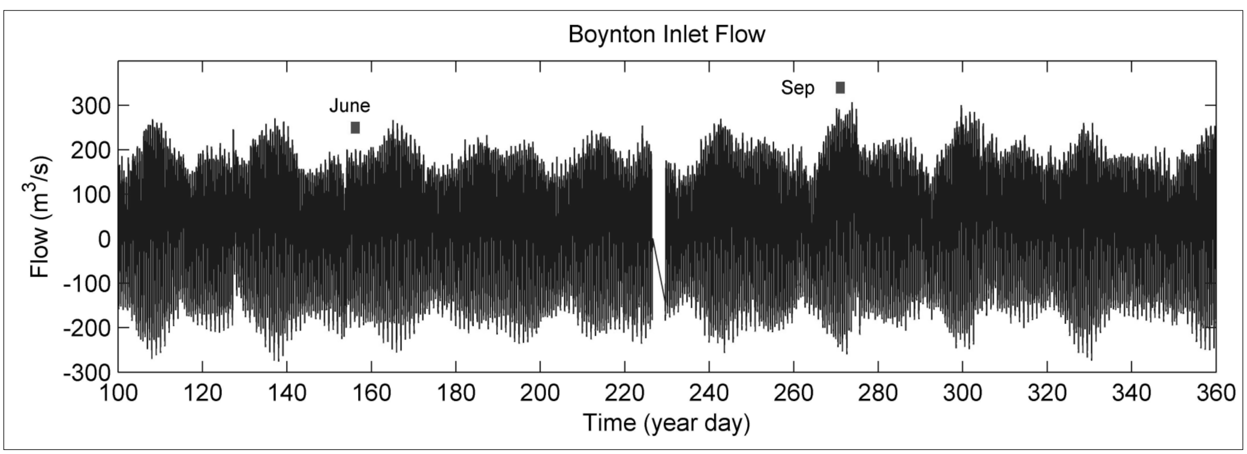

Figure 3. Water flow through the Boynton Inlet during 2007. Positive flow values refer to ebb tide; flood tides are denoted by negative flow values. The times for the two intensives are shown by small squares. Data are from Stamates (unpublished).

4.2 Nutrient Concentrations

Samples were obtained during the June 4-6 intensive according to a predetermined sampling schedule. The schedule was designed to sample four outgoing (ebb) and four incoming (flood) tides. Samples for nutrient analysis were taken every half-hour from midnight (EDT) 3-June through midnight 4-June, plus five blanks (102 samples). Microbiological samples were taken on a different schedule: every two hours for enterococci/*E. coli* and every six hours for molecular analysis during the outgoing tide. The samples were analyzed at AOML according to the procedures described in section 3.4 and at FAU according to the procedures described in Bloetscher and Meeroff (2006). Results are presented in Figures 4a and 4b. All data are listed numerically in the appendices. Orthophosphate (P) samples were believed to be contaminated and these results are not reported.

For the September intensive, the sampling schedule was modified. Samples were obtained for nutrients every half-hour on the outgoing tide and every hour on the incoming tide. Samples for molecular analysis were obtained once per outgoing tide. Samples for stable isotope analysis were taken every hour (outgoing tide) or every two hours (incoming tide). Again, four outgoing and four incoming tidal flows were sampled. Results are shown graphically in Figure 5 and are listed in the appendices. Nutrient concentrations averaged over each ebb or flood tide pulse are shown for both intensives in Figure 6. It is noted that the September intensive concentrations for all nutrients decreased rapidly through the intensive, with concentrations at the end of the intensive approximate to those of the June intensive. As sampling began a short time after the first tidal cycle began, and ended before the last tidal cycle ended, data completing the tidal cycles were estimated for Figure 6 using the average concentration from that tidal pulse.

As one would expect, flood tide water was from the coastal marine environment and was found to be quite low in nutrients. In contrast, the ebb tide waters were elevated in nutrients and microbiological markers and highly colored. Significant variations in the concentrations were observed in the four ebb tide pulses from each intensive. An important consideration is that the inlet flow rates were about 50% higher in the September intensive than in the June intensive.

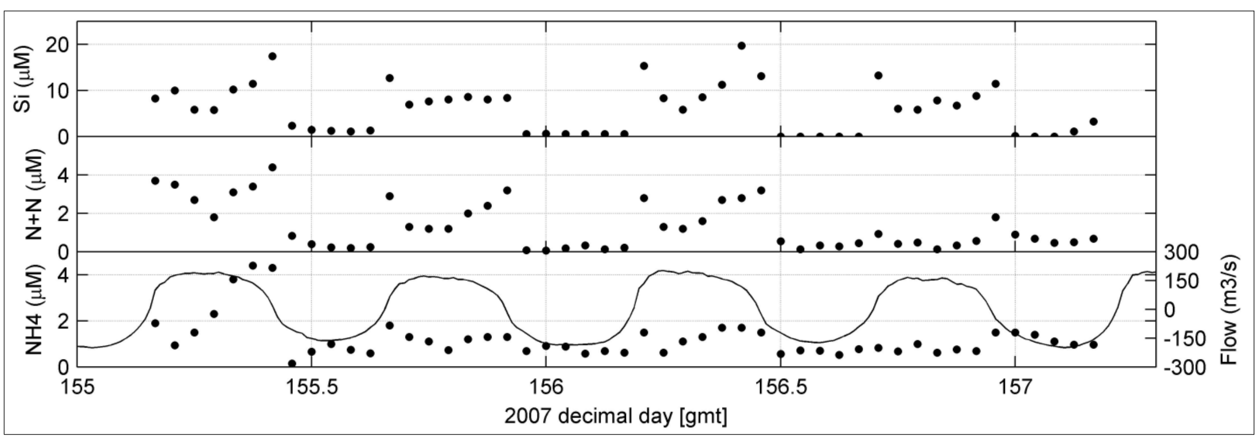

Figure 4a. Concentration data from AOML for the June 2007 intensive versus time (GMT). The solid line (bottom panel) represents the flow through the inlet (right-hand axis), with positive values being seaward (ebb tide) flow.

Figure 4b. Concentration data from FAU for the June 2007 intensive versus time (GMT). The solid line (bottom panel) represents the flow through the inlet (right-hand axis), with positive values being seaward (ebb tide) flow.

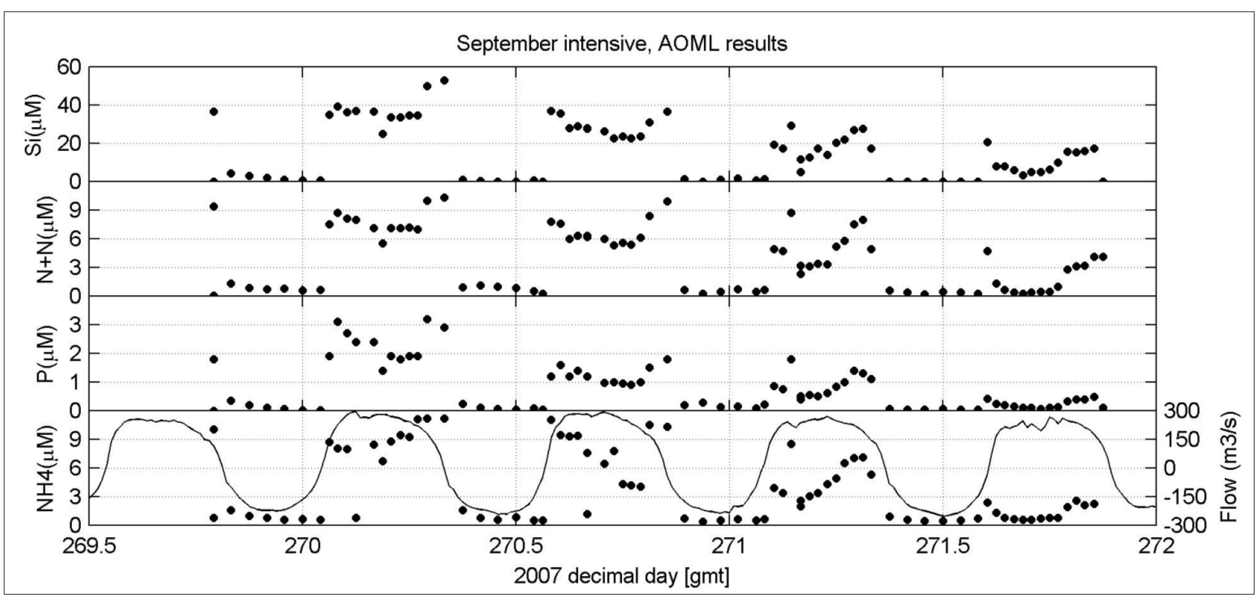

Figure 5. Concentration data for Si, N+N, P, and NH_4 for the September 2007 intensive, all versus time (GMT). As in Figures 4a and 4b, the solid line (bottom panel) represents the flow through the inlet (right-hand axis), with positive values being seaward (ebb tide) flow. Note the higher flow rates in comparison to the June intensive.

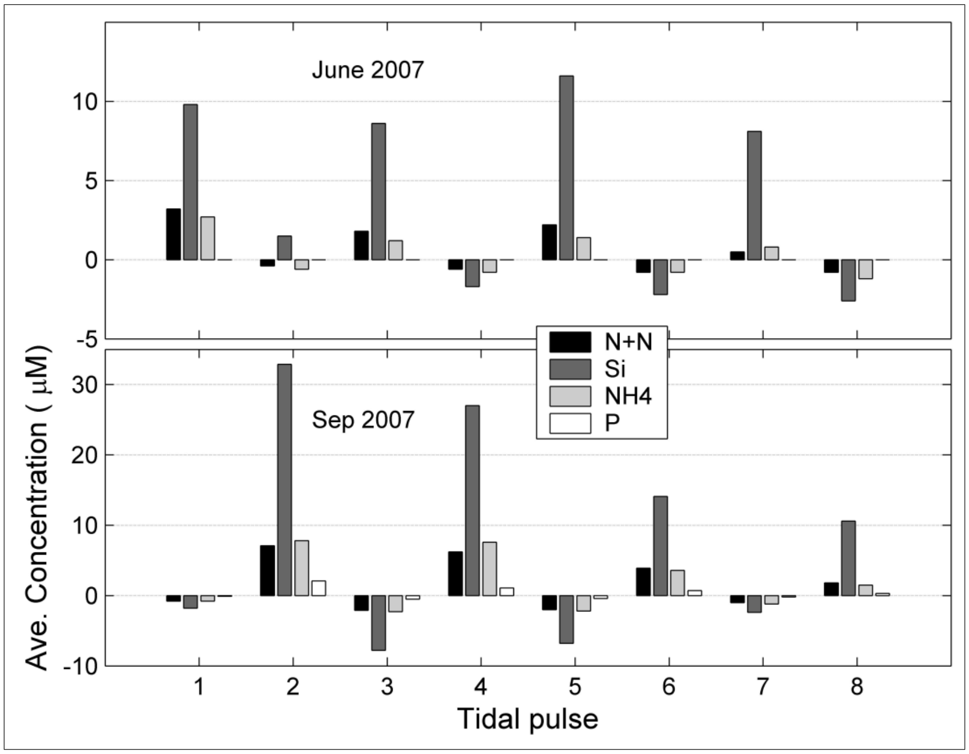

Figure 6. Averaged concentrations of N+N, Si, NH_4, and P for the June 2007 (upper panel) and September 2007 (lower panel) intensives plotted across the eight tidal pulses. Flood tide concentrations are plotted as negative for ease of visualization. The June 2007 intensive began on an ebb tide, while the September 2007 intensive began on a flood tide.

In addition, we note that the highest concentrations of N+N, NH_4, and Si during both intensives were generally obtained not at the time of maximum flow, but rather when the flow was minimal (maximum in first derivative of velocity). While the data do not provide an explanation for these observations, they suggest that the flow characteristics from the lagoon through the inlet were different for different flow rates and that nutrient concentrations in the lagoon were not spatially homogeneous.

4.3 Nutrient Ratios

The ratio of the nutrients during different times in the tidal cycle should provide information regarding the composition of the source water, as well as the homogeneity of the Boynton Inlet flow. We saw in Figure 4 that inbound flow concentrations were much lower than outbound, and that there was often an elevated concentration at the lower flow rates. In Figure 7 we present some relevant nutrient ratios. On the upper panels in Figure 7 are shown selected nutrient ratios from flood tide samples compared to ebb tide samples. The nutrient ratios for ebb

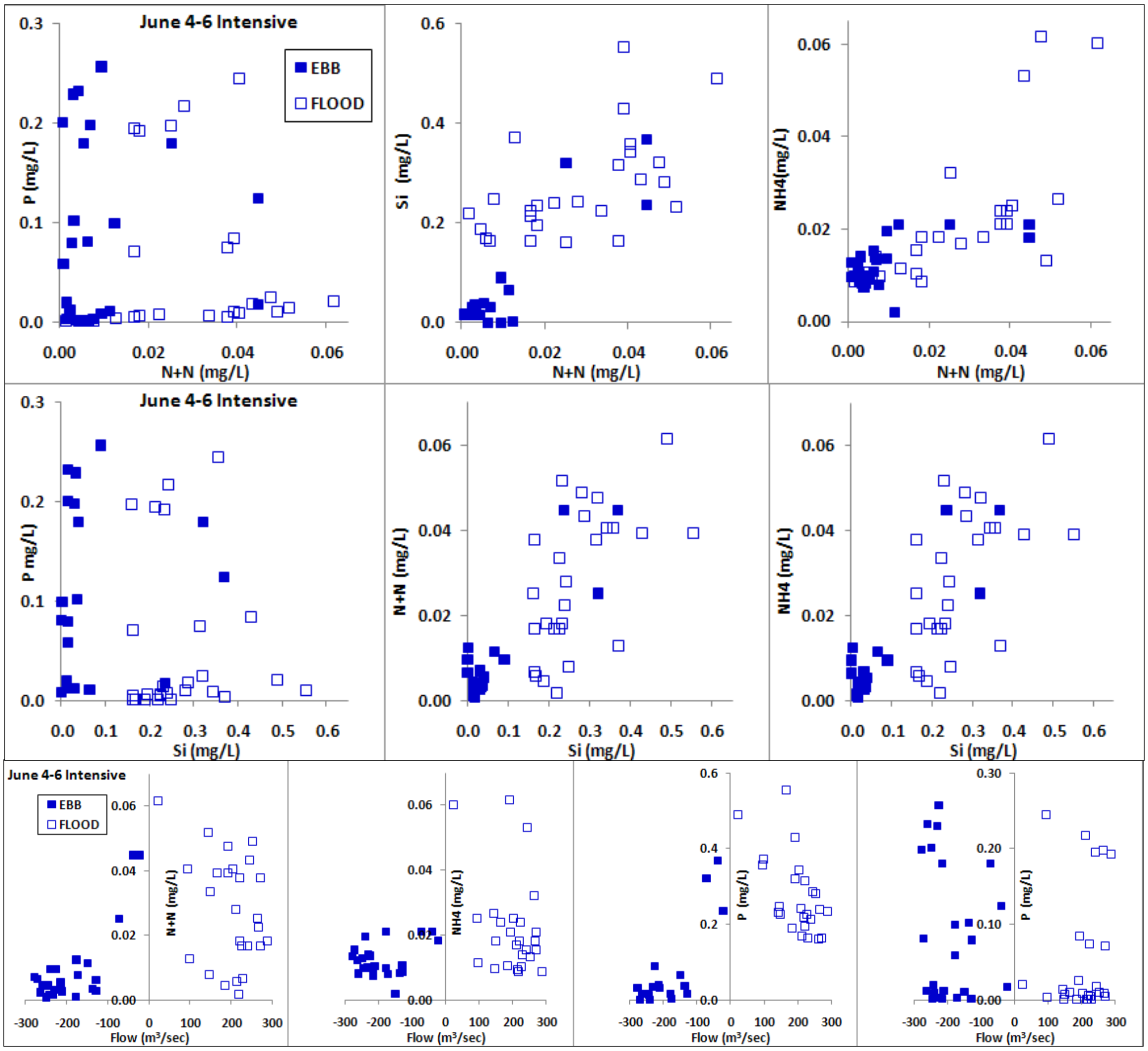

Figure 7. Nutrient concentration data from the June 2007 sampling intensive. Upper two panels: various nutrient ratios are given; open symbols refer to outbound flow measurements while closed symbols indicate inbound flow measurements. These data suggest that the incoming water is fundamentally different in nature than the outgoing water (in contrast with the September 2007 results, see Figure 8). The lower panel shows the concentration of measured nutrients versus inlet flow (inbound flow is negative, outbound is positive). Higher concentrations at low flow rates are also evident. Regressions are not shown because they were not statistically significant. Note the lack of disparity between ebb versus flood tide concentrations for orthophosphate (P).

and flow tide samples are distinctly different, strongly implying that the water masses are dissimilar. This is in contrast to the analogous data from the September intensive presented in Figure 8 (recall that in September samples were taken half-hourly during the outgoing flow but hourly during the incoming flow). From the September data, the flood and ebb water mass characteristics appear to be similar, suggesting that the outgoing water can be viewed as a more-or-less homogeneous mass of anthropogenically-impacted water, diluted with low-nutrient flood tide (coastal marine) water. The June intensive data (Figure 7) suggests more complex sources of nutrients, possibly changing during the course of the intensive.

A close examination of the September concentration data revealed that a portion of the samples had elevated concentrations of all the nutrients, but in the ebb tide samples only. These samples, characterized by orthophosphate values >0.06 mg/L, are separately denoted in Figure 8 (green triangles). The concentration ratios for this subset of samples were also quite different than for the rest of the ebb or flow water masses for Si and P (Figure 8, upper panels). These data suggest that these samples were derived from a different and distinct source of the water within the Lake Worth Lagoon that exited during ebb tidal flow. It also demonstrates the value of nutrient ratio analysis in elucidating the characteristics of the ebb and flood waters. Further characterization of these complex flow patterns would be helpful in understanding this behavior.

4.4 Homogeneity of Flow at the Bridge

To determine if there were consistent concentration gradients across the north-south extent of the inlet during the September 2007 intensive, samples were taken nearly simultaneously from locations A, B, and C (see Figure 2); these results are given in Table 2. These measurements were then scaled by dividing each measurement by the average from the three locations; these are plotted in Figure 9. No consistent gradient is evident, implying that the waters at this point in the inlet were well mixed in the north-south direction (e.g., ANOVA results for location, p=0.92 for N+N).

Table 2: Results from the three sampling locations on the Boynton Inlet bridge.

Day-Hour EDT	Decday GMT	Test Tube	N+N µM	NO_2 µM	NO_3 µM	Si µM	P µM	TDP µM	DOP µM
9/26/2007 22:00	270.083333	11A	8.7	0.75	7.95	39.2	3.1	3.43	0.33
9/26/2007 22:00	270.083333	11B	8.10	0.59	7.51	36.1	2.7	2.81	0.11
9/26/2007 22:00	270.083333	11C	7.3	0.56	6.74	31.7	2.1	2.70	0.60
9/27/2007 10:00	270.583333	30A	7.8	0.54	7.26	36.7	1.2	2.64	1.44
9/27/2007 10:00	270.583333	30B	7.4	0.42	6.98	34.3	1.3	2.70	1.40
9/27/2007 10:00	270.583333	30C	8.4	0.64	7.76	37.1	1.5	2.61	1.11
9/27/2007 23:00	271.125000	51A	4.7	0.45	4.25	17.2	0.75	1.21	0.46
9/27/2007 23:00	271.125000	51B	4.9	0.53	4.37	17.5	0.8	1.15	0.35
9/27/2007 23:00	271.125000	51C	3.9	0.4	3.5	12.6	0.76	1.07	0.31
9/28/2007 11:00	271.625000	70A	4.7	0.44	4.26	20.5	0.42	1.15	0.73
9/28/2007 11:00	271.625000	70B	4.1	0.37	3.73	16.6	0.5	1.18	0.68
9/28/2007 11:00	271.625000	70C	3.9	0.33	3.57	20	0.58	0.97	0.39

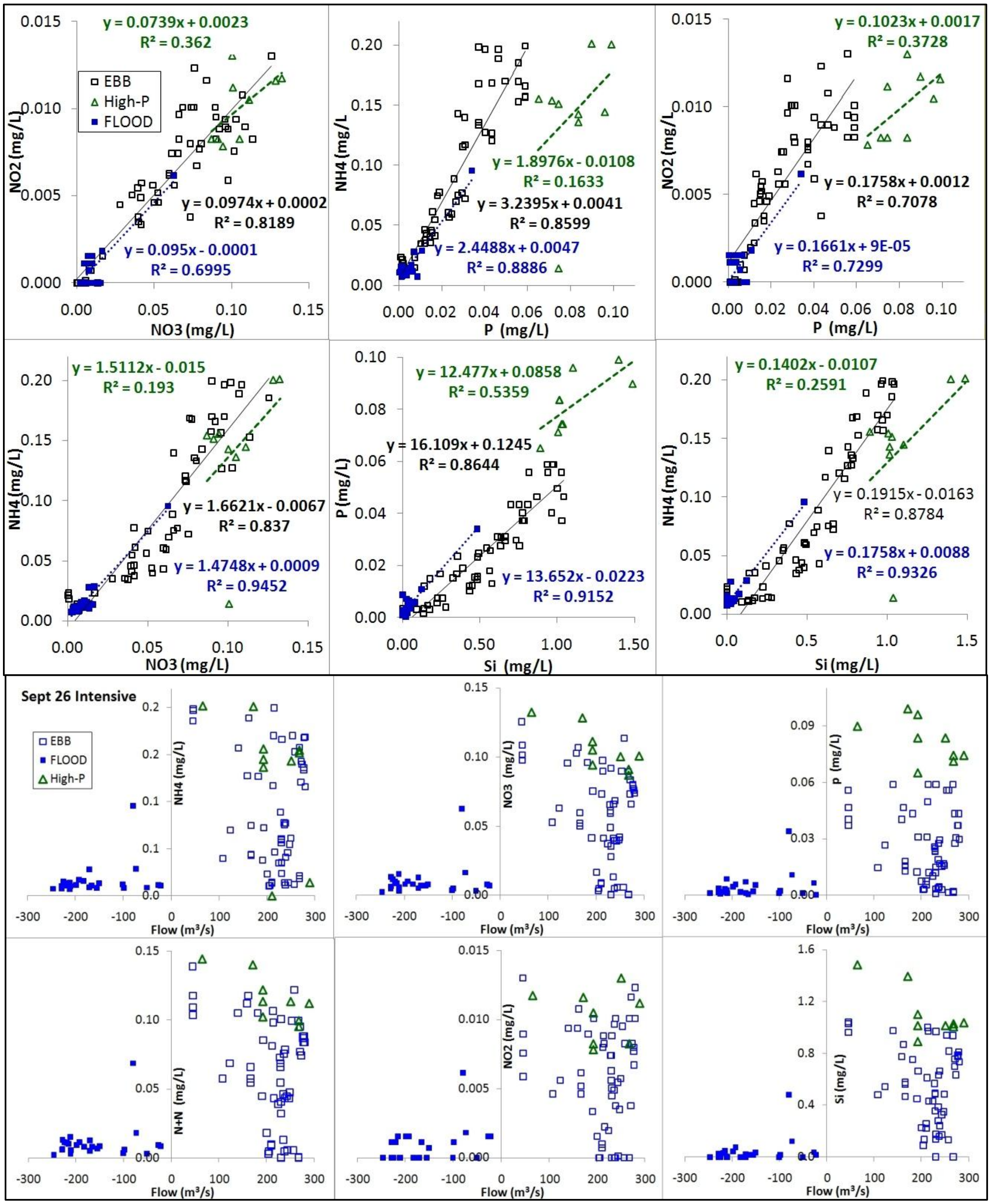

Figure 8. Nutrient concentrations during the September 2007 sampling intensive. The upper two panels plot various nutrient concentrations. Results where P (orthophosphate) > 0.06 mg/L are indicated by green triangles; results where P ≤ 0.06 mg/L are denoted by solid black squares for incoming flow and open blue squares for outgoing flow. Regression statistics for each are shown; the flood tide data are in blue; the ebb tide data in black. The lower two panels show the indicated concentrations plotted versus flows into (negative flows) and out of (positive flows) the inlet. Samples with P > 0.06 mg/L (green triangles) were seen to have generally high ebb tide concentrations for all analytes.

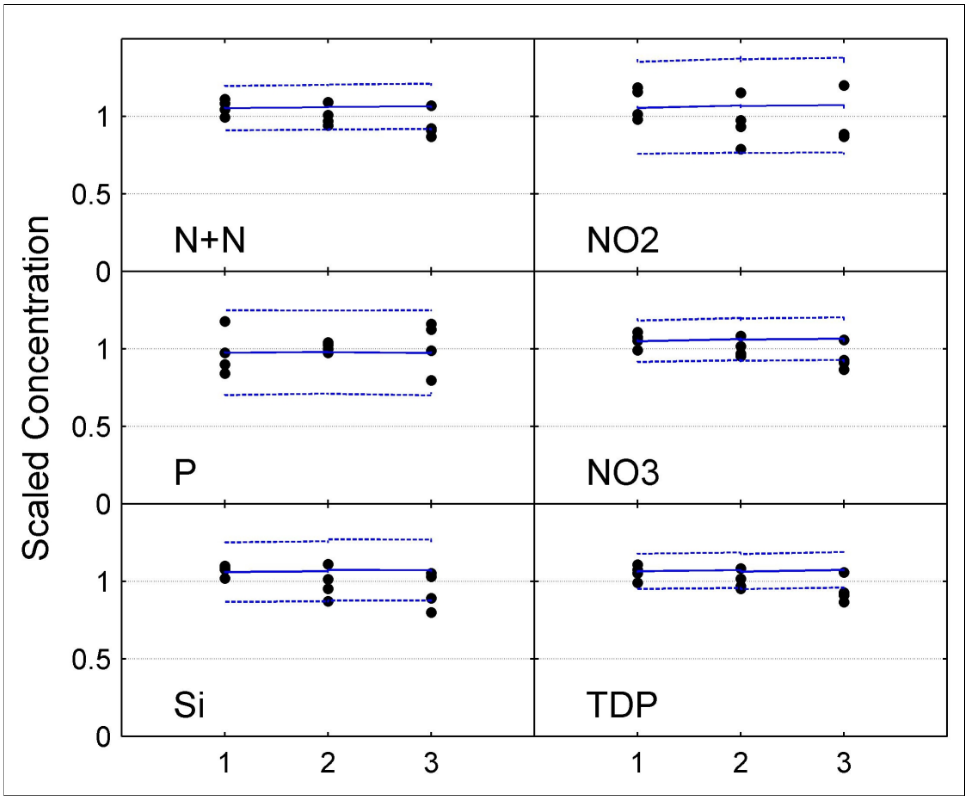

Figure 9. Scaled nutrient concentrations from the three sampling locations (A, B, and C) on the Boynton Inlet Bridge. Fitted curve is denoted by the solid line, ±2σ confidence bounds by dotted lines.

4.5 Nutrient Fluxes

The flux of material exiting the inlet into the coastal ocean was computed from the corrected flow data obtained at the inlet from the side-looking ADCP (section 2.2) and with the nutrient concentrations obtained during the two sampling intensives. These data are shown in Figure 10 and in Table 3.

Because the intensives did not start or end exactly at the beginning or end of their tidal cycles, the concentrations of pulses 1 and 8 reported in Table 3 have been approximated for the those entries by approximating the flow and using the averaged measured concentrations during those pulses.

As expected, these results demonstrate that the outgoing tide contains significant amounts of nutrients. We may compare these values to other known sources of nutrient input into the coastal ocean. For example, in Table 4 and Figure 11 are shown the reported daily flux totals for nutrients from four treated-wastewater plant ocean outfalls near the Boynton Inlet estimated from average output concentrations (average of monthly averages, Koopman *et al.*, 2006) and average daily outflow (FDEP, 2010). The inlet flux is on the order of a magnitude equivalent to the ocean outfalls, particularly for the September intensive data.

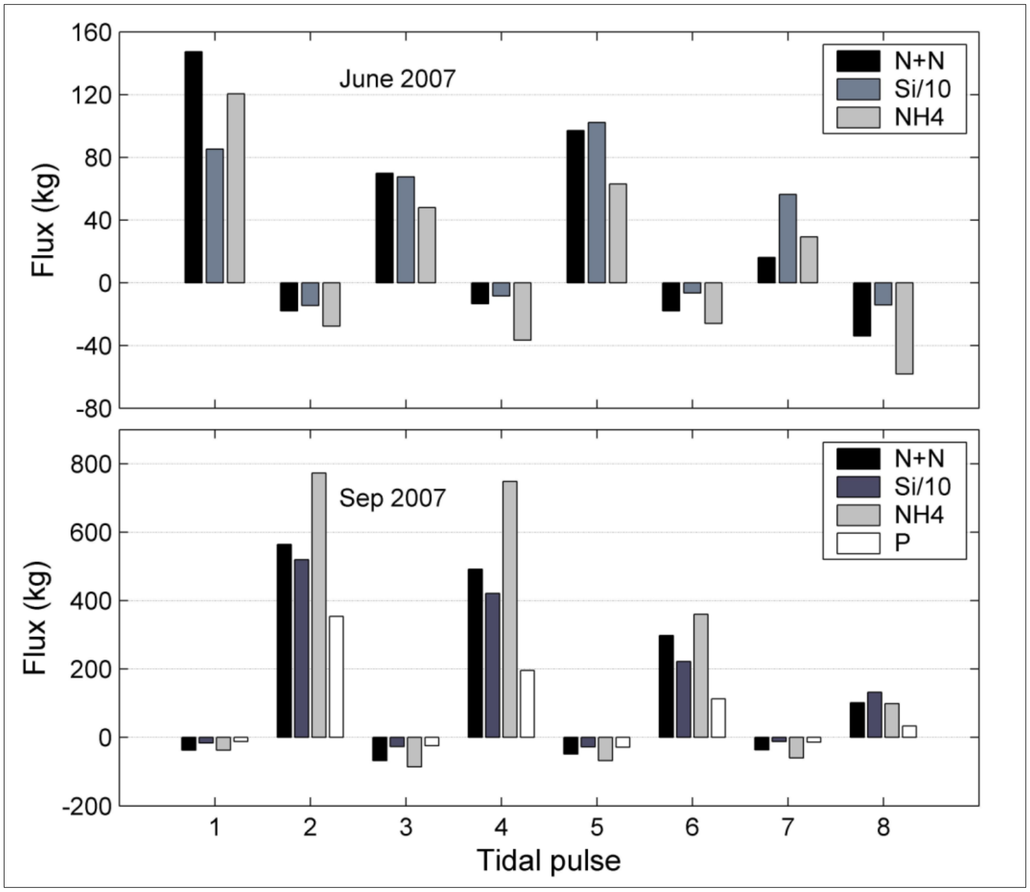

Figure 10. Comparison of nutrient loading between the two 48-hour intensive sampling periods: June 2007 (upper panel) and September 2007 (lower panel). Note that silicate concentrations have been divided by ten for a more efficient presentation.

Table 3: Net mass (kg) of nutrients into the coastal ocean for eight ebb and flood tidal pulses.

	Unit	1	2	3	4	5	6	7	8	Ebb Average	Flood Average
June:											
N+N	kg N	147.3	-18.0	69.7	-13.5	97.1	-18.0	16.1	-33.9	82.6	-20.9
Si	kg Si	852.2	-145.9	674.4	-84.7	1022.0	-65.6	563.7	-142.3	778.1	-109.6
NH_4	kg N	120.4	-27.8	47.9	-36.7	63.0	-25.9	29.2	-58.2	65.1	-37.1
September:											
N+N	kg N	-37.0	564.7	-67.7	492.2	-48.2	298.1	-36.3	101.3	364.1	-47.3
NO_2	kg N	-4.7	49.2	-1.9	52.3	-5.4	29.1	-1.5	6.0	34.1	-3.4
NO_3	kg N	-32.3	515.5	-65.8	439.9	-42.8	269.0	-34.8	95.3	329.9	-43.9
Si	kg Si	-162.8	5,196.5	-267.0	4,214.6	-276.4	2,221.6	-118.6	1,320.3	3,238.2	-206.2
P	kg P	-12.1	354.1	-24.4	196.0	-28.4	112.8	-13.6	33.6	174.1	-19.6
NH_4	kg N	-37.6	773.2	-86.5	748.7	-67.9	359.9	-59.6	98.8	495.2	-62.9

Table 4: Flux of nutrients from four treated-wastewater plant ocean outfalls near the Boynton Inlet.

Outfall	Outflow MGD	TSS mg/L	NH_4 mgN/L	NH_4 kgN/d	N+N mgN/L	N+N kgN/d	TN mgN/L	TN kgN/d	TP mgP/L	TP kgP/d
Boynton-Delray	12.9	9	11.7	571.3	4.1	200.2	18.7	913.2	1.7	83.0
Boca Raton	10.3	6	10.5	409.4	3.3	128.7	16.9	658.9	0.7	27.3
Broward	37.4	7	na	na	na	na	14.8	2095.3	1.3	184.0
Hollywood	36.7	17	11.9	1653.2	1.2	166.7	16.6	2306.1	1.1	152.8

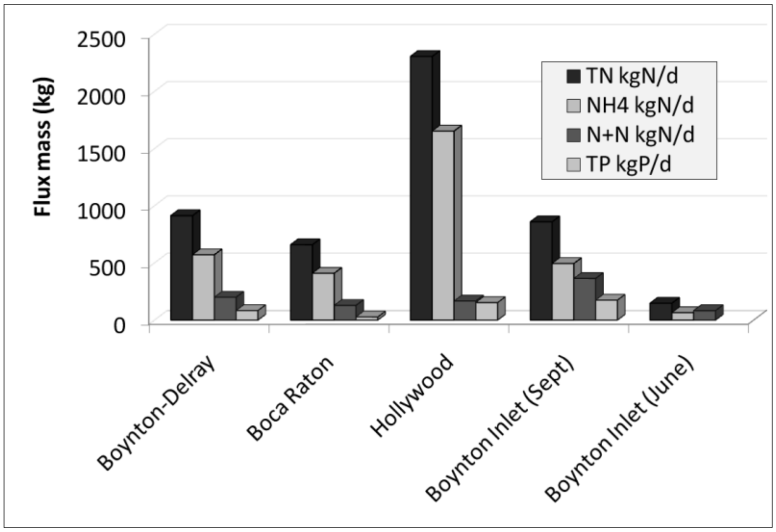

Figure 11. Comparison of nutrient fluxes from three treated-wastewater plant ocean outfalls and the two 48-hour sampling intensives at Boynton Inlet. For the intensives, we have approximated TN as NH_4 plus N+N concentrations, and TP as orthophosphate (P); P was not measured during the June intensive.

4.6 Inputs into the Lake Worth Lagoon

Considering Figure 3 and Figure 6, we see that the September intensive was characterized by considerably higher concentrations, as well as much higher water flow through the inlet. The resulting flux of nutrients through the Boynton Inlet (Figure 9) is characterized by considerable variation in outflowing nutrient masses for the eight ebb tide pulses. As was noted in the discussion of the nutrient concentrations, the nutrient fluxes observed in the September intensive were quite elevated at the beginning of the intensive, decreasing throughout the intensive until approximately equal to those found more or less throughout the June intensive. We may thus consider the June intensive values to be characteristic of a “normal” nutrient flux through the inlet, with the September results indicative of an elevated concentration event. The most likely cause of such an event is an increase in land-based pollution provided through elevated canal flow and/or elevated rainfall.

To elucidate these scenarios, we examined inputs into the Lake Worth Lagoon prior to the June and September intensives. Figure 12 shows canal flow through the C-16, C-17, and C-51 canals (upper panels) and rainfall in the vicinity of the lagoon (DBHYDRO sites 16674, 16583, and 16675) (lower panels).

A very strong rain event occurred on June 2, 2007 (day 153), dropping over 11 cm of rain, which resulted in a large total canal flow on that day; the following days had nearly no rainfall. The low levels of N+N and NH_4 (Figure 6) suggest that by the time of the intensive on June 4th (day 155) a "washing out" of these excess nutrients in the lagoon was substantially completed. In contrast, for the September intensive, rain was present up to the beginning of the intensive; canal flow was decreasing but still substantial. The "washing out" of the nutrients was still in progress during the time of the intensive, leading to high but decreasing nutrient fluxes.

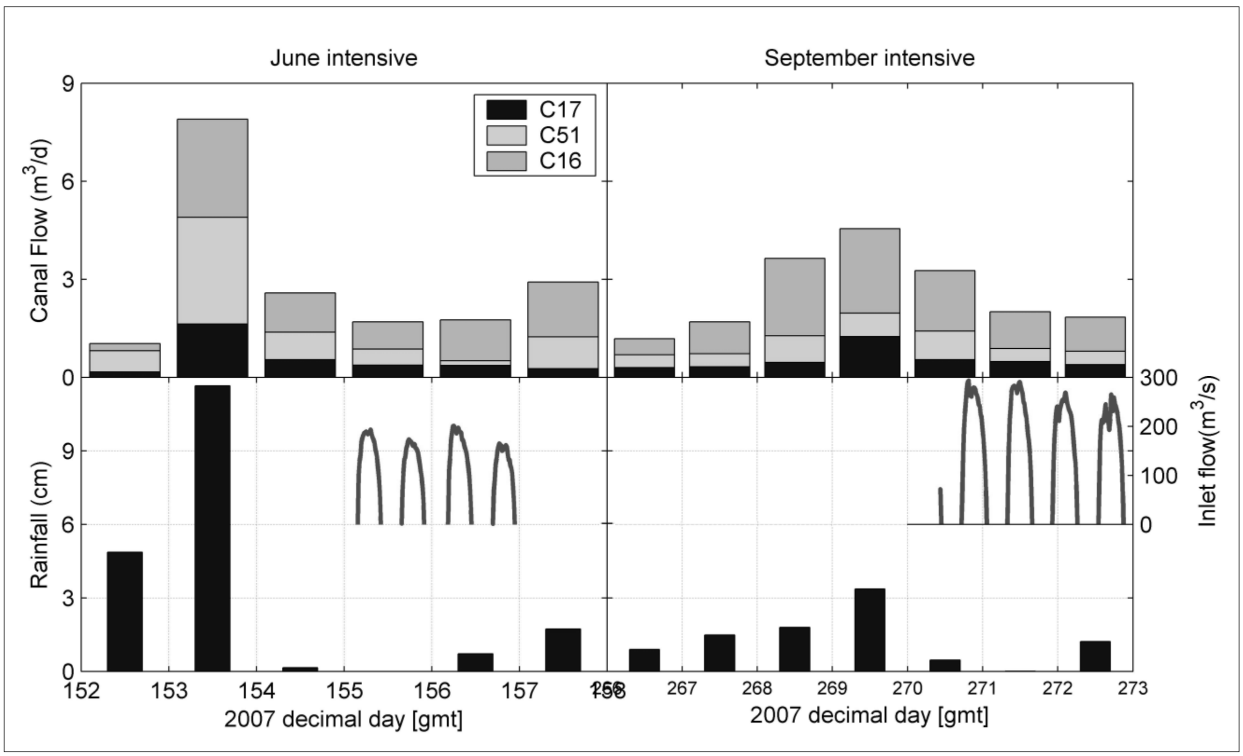

Figure 12. Canal (C-16, C-17, C-51) and inlet ebb tide water flow (upper panels) and rain (lower panels) for the June 2007 (left panels) and September 2007 (right panels) intensives. Sinusoidal lines indicate ebb tide flow through the inlet during each intensive. Flow and rain data are from the Florida Department of Environmental Protection (DBHYDRO).

4.7 Microbiology

A selected subset of the data collected is presented in Table 5 and in Appendices 3 and 4. The inlet appears to be a source of microbial contaminants to nearshore waters, as indicated by the higher percentage of positive detections for pathogens, fecal indicator bacteria (FIB), and source tracking markers associated with the outgoing tide versus the incoming tide (Figure 13).

Table 5: Detection of pathogens from the Boynton Inlet tidal cycles.

Detection	Outgoing Tide	Incoming Tide
Live enterococci fecal indicator bacteria above U.S. EPA recommended levels	1 in 5 tides (52 cfu/100 mL)	None in 5 tides
Human-source enterococci fecal indicator bacteria	2 in 5 tides	None in 5 tides
Human-source *Bacteriodes* fecal indicator bacteria	4 in 5 tides	1 in 5 tides
Pathogenic gastrointestinal bacteria (*salmonella*, *E. coli* O147:H7, and *Campylobacter jejuni*)	None in 5 tides	None in 5 tides
Potentially pathogenic drug-resistant *Staphylococcus aurens*	3 in 5 tides	None in 5 tides
Pathogenic protozoan *Cryptosporidium* oocysts	3 in 5 tides (2.4, 6.3, and 24.9 cysts/100 L)	None in 5 tides
Pathogenic protozoan *Giardia* cysts	3 in 5 tides (1.2, 4.2, and 19.4 cysts/100 L)	None in 5 tides
Human adenovirus	3 in 5 tides	1 in 5 tides
Human noroviruses	2 in 5 tides	None in 5 tides
Human enteroviruses	2 in 5 tides	None in 5 tides

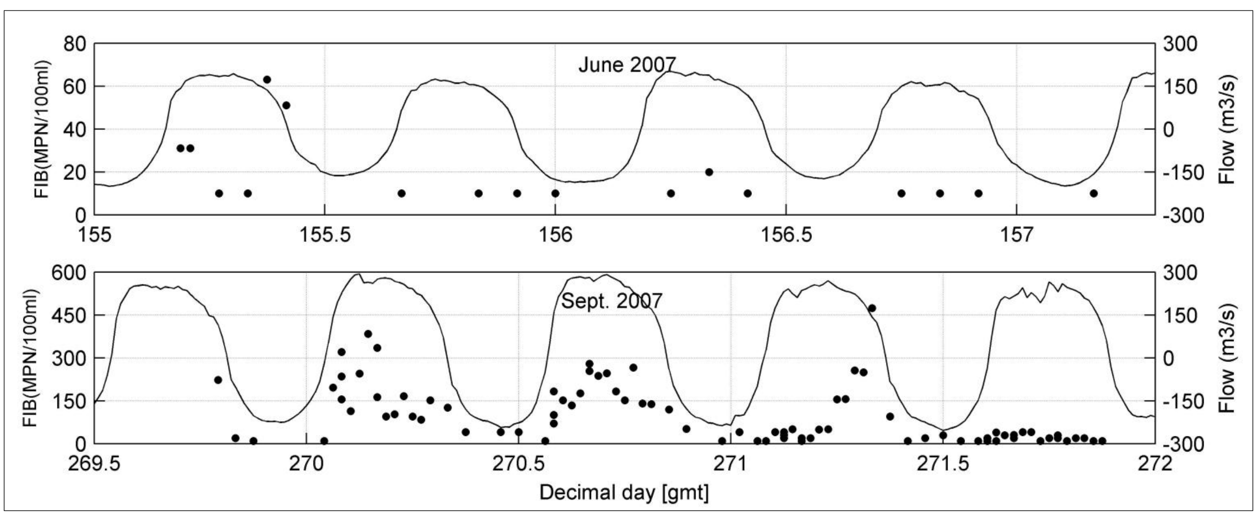

Figure 13. Fecal indicator counts for the June 2007 (top panel) and September 2007 (bottom panel) sampling intensives. Black line denotes flow through the inlet (right vertical axis), with outbound (ebb) flow as positive.

A variety of microbial contaminants were detected in outgoing tides from the inlet (Figure 14). In comparison, water samples taken from the boil and near the bottom of the South Central wastewater-treated plant ocean outfall (the closest outfall to Boynton Inlet) did not yield positive results during a 2006 field campaign (Carsey *et al.*, 2010). A low amount of enterococci DNA (<30 genome equivalents) was detected at the South Central wastewater-treated plant boil during a July 2008 cruise, and the abundance declined with distance from the outfall (Figure 15).

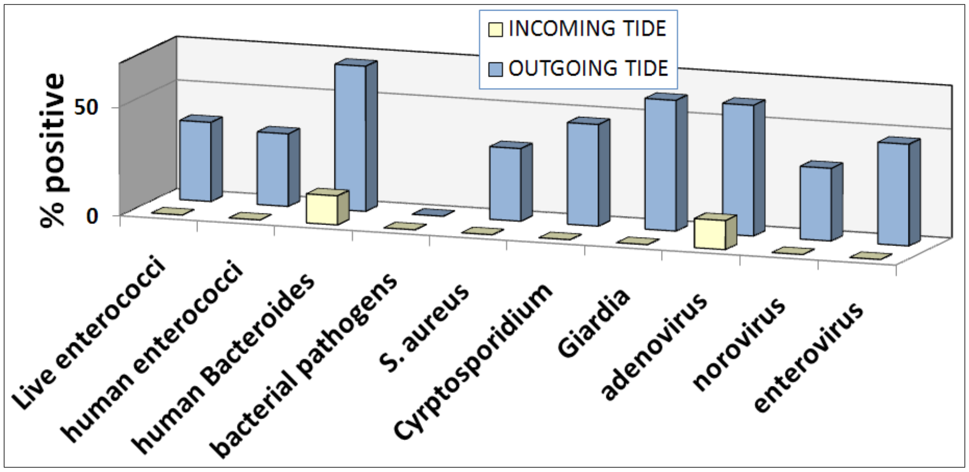

Figure 14. Breakdown of results by test for the September 2007 sampling intensive. Data show the percentage of samples with a positive detection for microbial contaminants out of 15 discrete time points. The category called "bacterial pathogens" is a composite for *C. jejuni*, *Salmonella* spp., and *E. coli* O157:H7.

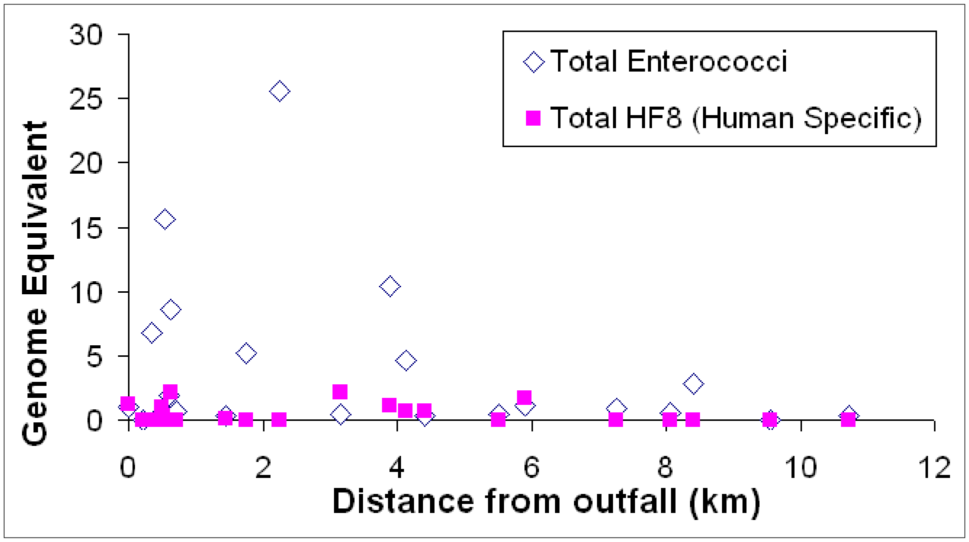

Figure 15. The abundance (genome equivalents) of enterococci and a human-specific *Bacteroides* (HF8) as measured by qPCR versus distance from the South Central wastewater-treated plant ocean outfall (data from a July 2008 R/V *Walton Smith* cruise, C. Sinigalliano, personal communication).

4.8 Nitrogen Isotopes

Samples were analyzed for $\delta^{15}N$ in ammonia according to the procedures described in section 3.3. The results appear in Tables 6 and 7 and Figure 16. Recall that the sampling strategy for the September intensive called for more ebb tide samples than flood tide samples. Although average ebb tide $\delta^{15}N$ values exceed flood tide values, variance is quite high and no clear pattern is evident.

Table 6: Nitrogen isotope results obtained from the September 2007 sampling intensive.

No.	Time (EDT)	$\delta^{15}NH_4$	No.	Time (EDT)	$\delta^{15}NH_4$	No.	Time (EDT)	$\delta^{15}NH_4$
1	9-26-2007 15:00	-4.30	29	9-27-2007 09:30	-0.44	55	9-26-2007 20:00	-0.22
4	9-26-2007 16:00	19.38	31	9-27-2007 10:30	-3.45	57	9-26-2007 21:30	0.44
6	9-26-2007 18:00	7.83	33	9-27-2007 11:30	-0.11	59	9-26-2007 22:30	-3.41
8	9-26-2007 20:00	2.44	36	9-27-2007 12:30	-1.76	61	9-26-2007 23:30	-4.41
10	9-26-2007 21:30	-4.62	38	9-27-2007 13:30	1.00	64	9-27-2007 00:30	8.93
12	9-26-2007 22:30	-8.19	40	9-27-2007 14:30	-0.93	68	9-27-2007 01:30	-5.23
14	9-26-2007 23:30	-1.96	42	9-27-2007 15:30	-3.56	69	9-27-2007 02:30	8.27
17	9-27-2007 00:30	0.06	44	9-27-2007 17:30	2.30	71	9-27-2007 05:00	3.76
19	9-27-2007 01:30	-4.98	46	9-27-2007 19:30	-6.90	74	9-27-2007 07:00	1.27
21	9-27-2007 02:30	-4.46	48	9-27-2007 21:30	-6.13	76	9-27-2007 09:30	7.01
24	9-27-2007 05:00	3.47	50	9-27-2007 22:30	-2.69	78	9-27-2007 10:30	7.91
26	9-27-2007 07:00	3.20	52	9-27-2007 23:30	0.90	80	9-27-2007 11:30	5.66

Table 7: Nitrogen isotope results averaged over ebb and flood tides.

Pulse	$\delta^{15}NH_4$ (‰)	NH_4 (μM)
E1	9.88	0.02
E2	2.07	0.02
E3	-3.58	0.01
E4	3.99	0.01
Average	3.09	0.01
F1	-4.02	0.16
F2	-1.47	0.15
F3	-1.56	0.07
F4	5.12	0.02
Average	-0.48	0.10

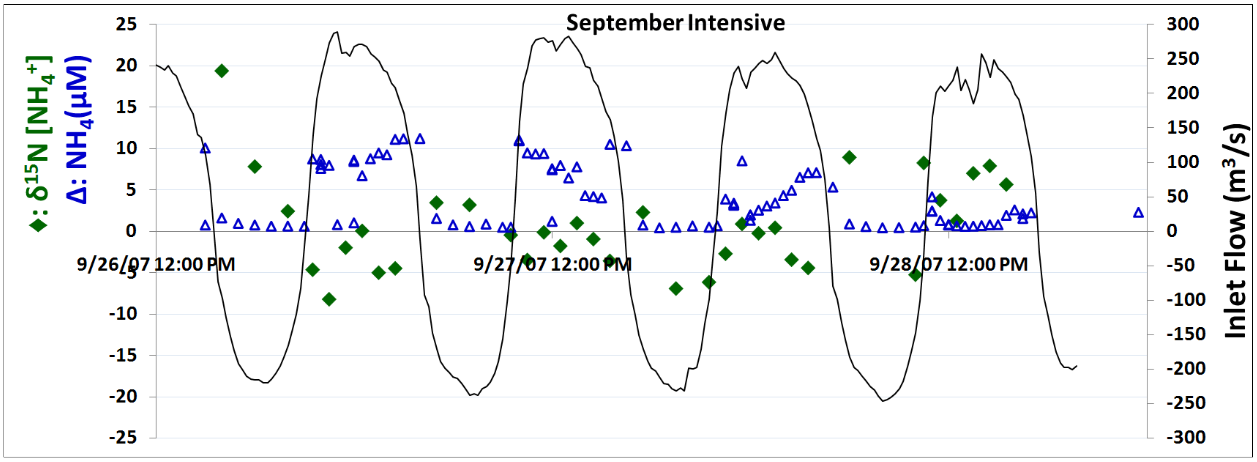

Figure 16. Stable isotope data with flow and ammonium concentrations from the September 2007 intensive. The diamond symbols indicate $\delta^{15}N$ values for ammonium; the triangle symbols indicate ammonium concentrations (left vertical axis). The black line indicates the flow through the inlet (right vertical axis).

5. Conclusions

Researchers with the FACE program collected a variety of data during two sampling intensives conducted in 2007, including nutrient, microbiological, and oceanographic information to help understand the processes that affect Florida's coastal environment and coral reef habitats. The nutrient flux from the inlet was found to be substantial, albeit quite variable, and comparable to that of nearby treated-wastewater plant ocean outfalls. The data also suggest that excess rain and canal flow leads to elevated nutrient concentrations in the inlet that are rapidly washed out of the inlet into the coastal ocean.

The data appear to stress the need to assess the coastal zone in a cohesive manner, especially if the data are to be used to determine the impacts of land-based pollutant sources, to control anthropogenic water discharges, for guidance in the operation and development of water and sewer infrastructure, and/or for the formulation of science-based regulation.

6. Acknowledgments

We wish to thank Florida Atlantic University, as well as students Heather Foy, Hatsuko Hamaguchi, Thais Bocca, Linda Hess, Anthony Ruffini, and Scott Ornitz for collecting water samples and for consistently recording detailed physical parameters throughout the 48-hour sampling periods. We value the collaboration with FAU on this study and appreciate their contributions to these data, including pH, salinity, and results from nutrient, TSS, and microbiology analyses.

Rosenstiel School of Marine and Atmospheric Science (RSMAS) graduate student Courtney Dryer provided nitrogen isotope ratio analysis for the water samples. Dr. Maribeth Gidley assisted in filtering efforts, and David Wanless conducted the real-time PCR analysis.

7. References

APHA-AWWA-WEF, 1995: *Standard Methods for the Examination of Water and Wastewater,* 19th edition. American Public Health Association, Washington, DC.

Bloetscher, F., and D. Meeroff, 2006: *Boynton Inlet Sampling event Phase II*, Draft A (November 2006).

Carsey, T.P., H. Casanova, C. Drayer, C. Featherstone, C. Fischer, K. Goodwin, J. Proni, A. Saied, C. Sinigalliano, J. Stamates, P. Swart, and J.-Z. Zhang, 2010: FACE outfalls survey cruise: October 6-19, 2006. NOAA Technical Report, OAR AOML-38, 130 pp. (CD-ROM).

EPA, 2005: Method 1623: *Cryptosporidium* and *Giardia* in water by filtration/IMS/FA. U.S. Environmental Protection Agency, Washington, DC, EPA-821-R-01-025, 72 pp.

FDEP, 2010: Implementation of chapter 2008-232, laws of Florida domestic wastewater ocean outfalls. 2010 Annual Report, Florida Department of Environmental Protection, Tallahassee, FL (http://www.dep.state.fl.us/water/wastewater/docs/ocean-outfall-2010.pdf).

He, J.W., and S. Jiang, 2005: Quantification of enterococci and human adenoviruses in environmental samples by real-time PCR. *Applied and Environmental Microbiology,* 71(5): 2250-2255.

Kong, R.Y.C., S.K.Y. Lee, T.W.F. Law, S.H.W. Law, and R.S.S. Wu, 2002: Rapid detection of six types of bacterial pathogens in marine waters by multiplex PCR. *Water Research,* 36(11):2802-2812.

Koopman, B., J.P. Heaney, F.Y. Cakir, M. Rembold, P. Indeglia, and G. Kini, 2006: Ocean outfall study. Final Report, Florida Department of Environmental Protection, Tallahassee, FL (http://www.dep.state.fl.us/water/reuse/docs/OceanOutfallStudy.pdf).

LaGier, M.J., L.A. Joseph, T.V. Passweretti, K.A. Musser, and N.M. Cirino, 2004: A real-time multiplexed PCR assay for rapid detection and differentiation of *Campylobacter jejuni* and *Campylobacter col. Molecular and Cellular Probes*, 18:275-282.

Layton, A., L. McKay, D. Williams, V. Garrett, R. Gentry, and G. Sayler, 2006: Development of *Bacteroides* 16S rRNA gene TaqMan-based real-time PCR assays for estimation of total, human, and bovine fecal pollution in water. *Applied and Environmental Microbiology,* 72(6):4214-4224.

Mason, W.J., J.S. Blevins, K. Beenken, N. Wibowo, N. Ojha, and M.S. Smeltzer, 2001: Multiplex PCR protocol for the diagnosis of *Staphylococcal* infection. *Journal of Clinical Microbiology,* 39:3332-3338.

Maurer, J.J., D. Schmidt, P. Petrosko, S. Sanchez, L. Bolton, and M.D. Lee, 1999: Development of primers to O-antigen biosynthesis genes for specific detection of *Escherichia coli* O157 by PCR. *Applied and Environmental Microbiology,* 65:2954-2960.

PBCDERM, 1990: Lake Worth Lagoon: Natural resources inventory and resource enhancement study. Palm Beach County Department of Environmental Resource Management, 226 pp.

Scott, T.M., T.M. Jenkins, J. Lukasik, and J.B. Rose, 2005: Potential use of a host associated molecular marker in *Enterococcus faecium* as an index of human fecal pollution. *Environmental Science and Technology*, 39(1):283-287.

Zhang, J.-Z., and G.A. Berberian, 1997: EPA Method 366.0: Determination of dissolved silicate in estuarine and coastal waters by gas segmented flow colorimetric analysis. U.S. Environmental Protection Agency, Washington, DC, EPA-600-R-97-072, 13 pp.

Zhang, J.-Z., C.J. Fischer, and P.B. Ortner, 1998: EPA Method 367.0: Determination of total phosphorus in estuarine and coastal waters by autoclave promoted persulfate oxidation. National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH.

Zhang, J.-Z., C.J. Fischer, and P.B. Ortner, 2001: Continuous flow analysis of phosphate in natural waters using hydrazine as a reductant intern. *Journal of Environmental Analytical Chemistry*, 80(1):61-73.

Zhang, J.-Z., P.B. Ortner, C.J. Fischer, and L.D. Moore, 1997a: EPA Method 349.0: Determination of ammonia in estuarine and coastal waters by gas segmented continuous flow colorimetric analysis. U.S. Environmental Protection Agency, Washington, DC, EPA-600-R-97-072, 16 pp.

Zhang, J.-Z., P.B. Ortner, and C.J. Fischer, 1997b: EPA Method 353.4: Determination of nitrate and nitrite in estuarine and coastal waters by gas segmented continuous flow colorimetric analysis. U.S. Environmental Protection Agency, Washington, DC, EPA-600-R-97-072, 20 pp.

Zimmermann, C.F., and C.W. Keefe, 1997: EPA Method 365.5: Determination of orthophosphate in estuarine and coastal waters by automated colorimetric analysis. U.S. Environmental Protection Agency, Washington, DC, EPA-600-R-97-072, 9 pp.

8. Appendices

Data elements common to both Boynton Inlet 48-hour intensive sampling periods are summarized in Appendices 1-6. Each sampling period has duplicate tables showing the principal nutrient concentration units µM and mg/L. Concentrations in relation to tidal flow are clearly shown, using (blue) incoming and (yellow) outgoing. Please note that some data elements may be present in one sampling period, but not in the other. The term “ns” denotes not sampled, while the term “na” denotes not available. Phosphate measurements were obtained during the June intensive sampling but were not included in summary graphics due to possible contamination of those samples. Total organic nitrogen was not available in September tables due to a breakdown of the analytical system at FAU, and nitrogen isotope ratio analysis was only performed in the September sampling period. Shaded rows denote samples taken during ebb tides (negative flow rates). Microbiology tables have tidal flows indicated by color.

Appendix 1. Nutrient Results—June 2007 Sampling Intensive.

Day-hour EDT	Day-hour GMT	Flow m^3/s	ADCP T(°C)	Along cm/s	Crs cm/s	N+N µM	Si µM	P µM	NH4 µM	N+N mg/L	Si mg/L	P mg/L	NH4 mg/L
6/4/2007 0:00	6/4/2007 4:00	99.6	26.61	70.7	0.8	3.70	8.20	0.46	1.90	0.052	0.230	0.014	0.027
6/4/2007 1:00	6/4/2007 5:00	176.4	26.54	128.1	16.7	3.50	10.00	0.31	0.94	0.049	0.281	0.010	0.013
6/4/2007 2:00	6/4/2007 6:00	189.6	26.63	143.9	13.7	2.70	5.80	0.16	1.50	0.038	0.163	0.005	0.021
6/4/2007 3:00	6/4/2007 7:00	185.4	26.56	147.1	11	1.80	5.70	6.40	2.30	0.025	0.160	0.198	0.032
6/4/2007 4:00	6/4/2007 8:00	173.1	26.48	142.3	5	3.10	10.20	0.58	3.80	0.043	0.286	0.018	0.053
6/4/2007 5:00	6/4/2007 9:00	135.7	26.46	114.8	9.8	3.40	11.40	0.82	4.40	0.048	0.320	0.025	0.062
6/4/2007 6:00	6/4/2007 10:00	16.3	26.45	13.9	3.9	4.40	17.40	0.66	4.30	0.062	0.489	0.020	0.060
6/4/2007 7:00	6/4/2007 11:00	-106.3	26.25	-91.7	-1.3	0.82	2.30	0.34	0.14	0.011	0.065	0.011	0.002
6/4/2007 8:00	6/4/2007 12:00	-152.3	26.26	-129.3	-2.1	0.39	1.40	5.80	0.66	0.005	0.039	0.180	0.009
6/4/2007 9:00	6/4/2007 13:00	-163.3	26.29	-132.8	-1.6	0.22	1.20	7.40	1.00	0.003	0.034	0.229	0.014
6/4/2007 10:00	6/4/2007 14:00	-148.3	26.37	-115.8	-0.7	0.19	1.10	0.39	0.74	0.003	0.031	0.012	0.010
6/4/2007 11:00	6/4/2007 15:00	-95.7	26.52	-72.3	-0.4	0.24	1.30	3.30	0.59	0.003	0.037	0.102	0.008
6/4/2007 12:00	6/4/2007 16:00	66.4	26.68	49.4	-0.3	2.90	12.70	7.90	1.80	0.041	0.357	0.245	0.025
6/4/2007 13:00	6/4/2007 17:00	155.3	27.25	118.0	-0.2	1.30	6.90	0.19	1.30	0.018	0.194	0.006	0.018
6/4/2007 14:00	6/4/2007 18:00	168.8	27.59	133.5	6.8	1.20	7.60	6.30	1.10	0.017	0.213	0.195	0.015
6/4/2007 15:00	6/4/2007 19:00	160.1	27.55	132.2	4.1	1.20	8.00	0.14	0.73	0.017	0.225	0.004	0.010
6/4/2007 16:00	6/4/2007 20:00	150.2	27.78	128.7	4.3	2.00	8.60	7.00	1.20	0.028	0.242	0.217	0.017
6/4/2007 17:00	6/4/2007 21:00	106.2	28.05	93.3	1.3	2.40	8.00	0.22	1.30	0.034	0.225	0.007	0.018
6/4/2007 18:00	6/4/2007 22:00	-15.8	28.19	-14.0	0.4	3.20	8.40	0.55	1.30	0.045	0.236	0.017	0.018
6/4/2007 19:00	6/4/2007 23:00	-127.2	27.85	-113.5	-1.8	0.07	0.53	1.90	0.69	0.001	0.015	0.059	0.010
6/4/2007 20:00	6/5/2007 0:00	-177.1	27.62	-155.2	-2.1	0.06	0.58	6.50	0.91	0.001	0.016	0.201	0.013
6/4/2007 21:00	6/5/2007 1:00	-186.4	27.42	-154.2	-1.7	0.17	0.55	0.38	0.88	0.002	0.015	0.012	0.012
6/4/2007 22:00	6/5/2007 2:00	-182.8	27.08	-143.7	-1.1	0.32	0.55	7.50	0.58	0.004	0.015	0.232	0.008
6/4/2007 23:00	6/5/2007 3:00	-169.7	26.93	-127.4	-0.5	0.12	0.49	0.63	0.69	0.002	0.014	0.020	0.010
6/5/2007 0:00	6/5/2007 4:00	-89.4	26.88	-64.5	-0.9	0.21	0.55	2.55	0.62	0.003	0.015	0.079	0.009
6/5/2007 1:00	6/5/2007 5:00	134.1	26.96	96.6	0.1	2.80	15.30	2.70	1.50	0.039	0.430	0.084	0.021
6/5/2007 2:00	6/5/2007 6:00	201.4	26.94	149.6	13.9	1.30	8.30	6.20	0.62	0.018	0.233	0.192	0.009
6/5/2007 3:00	6/5/2007 7:00	190.3	26.98	147.5	10.4	1.20	5.80	2.30	1.10	0.017	0.163	0.071	0.015
6/5/2007 4:00	6/5/2007 8:00	188.3	26.96	152.4	4.2	1.60	8.50	0.26	1.30	0.022	0.239	0.008	0.018
6/5/2007 5:00	6/5/2007 9:00	157.5	26.97	132.1	-0.4	2.70	11.20	2.40	1.70	0.038	0.315	0.074	0.024
6/5/2007 5:30	6/5/2007 9:30	144.3	27.00	122.3	7	2.90	12.20	0.28	1.80	0.041	0.343	0.009	0.025
6/5/2007 6:00	6/5/2007 10:00	117.5	27.04	100.7	6.9	2.80	19.70	0.32	1.70	0.039	0.553	0.010	0.024
6/5/2007 7:00	6/5/2007 11:00	-27.6	27.06	-23.8	-1.1	3.20	13.10	4.00	1.50	0.045	0.368	0.124	0.021
6/5/2007 8:00	6/5/2007 12:00	-122.5	26.68	-106.5	-1.7	0.55	0.00	0.10	0.56	0.008	0.000	0.003	0.008
6/5/2007 9:00	6/5/2007 13:00	-165.3	26.56	-140.6	-0.6	0.12	0.00	0.09	0.71	0.002	0.000	0.003	0.010
6/5/2007 10:00	6/5/2007 14:00	-173.4	26.58	-141.0	-0.5	0.32	0.00	0.05	0.70	0.004	0.000	0.001	0.010
6/5/2007 11:00	6/5/2007 15:00	-150.8	26.69	-117.7	0	0.28	0.00	0.04	0.52	0.004	0.000	0.001	0.007
6/5/2007 12:00	6/5/2007 16:00	-90.1	26.84	-67.9	-0.4	0.45	0.00	0.06	0.77	0.006	0.000	0.002	0.011
6/5/2007 13:00	6/5/2007 17:00	68.5	27.17	51.2	-0.6	0.92	13.20	0.13	0.82	0.013	0.371	0.004	0.011
6/5/2007 14:00	6/5/2007 18:00	150.0	27.66	114.6	1.6	0.41	6.00	0.04	0.67	0.006	0.169	0.001	0.009
6/5/2007 15:00	6/5/2007 19:00	161.5	27.97	128.6	4	0.48	5.80	0.05	1.00	0.007	0.163	0.001	0.014
6/5/2007 16:00	6/5/2007 20:00	154.5	27.77	127.6	3	0.12	7.80	0.03	0.62	0.002	0.219	0.001	0.009
6/5/2007 17:00	6/5/2007 21:00	130.8	27.86	111.4	1.3	0.32	6.70	0.05	0.76	0.004	0.188	0.001	0.011
6/5/2007 18:00	6/5/2007 22:00	104.1	27.80	91.0	1.2	0.56	8.80	0.02	0.69	0.008	0.247	0.001	0.010
6/5/2007 19:00	6/5/2007 23:00	-51.5	27.59	-45.2	-1.6	1.80	11.40	5.80	1.50	0.025	0.320	0.180	0.021
6/5/2007 20:00	6/6/2007 0:00	-125.5	27.02	-110.2	-1.9	0.89	0.08	3.20	1.50	0.012	0.002	0.099	0.021
6/5/2007 21:00	6/6/2007 1:00	-170.5	26.63	-146.9	-1.9	0.68	0.00	0.28	1.40	0.010	0.000	0.009	0.020
6/5/2007 22:00	6/6/2007 2:00	-191.2	26.39	-156.5	-1.3	0.46	0.00	2.60	1.10	0.006	0.000	0.081	0.015
6/5/2007 23:00	6/6/2007 3:00	-194.9	26.46	-151.6	-0.5	0.50	1.10	6.40	0.96	0.007	0.031	0.198	0.013
6/6/2007 0:00	6/6/2007 4:00	-157.5	26.51	-117.0	-0.4	0.68	3.20	8.30	0.97	0.010	0.090	0.257	0.014

Appendix 2. Nutrient Results—September 2007 Sampling Intensive.

Day-Hour (EDT)	Flow (m^3/s)	Sample No.	N+N µM	NO_2 µM	NO_3 µM	Si µM	P µM	TDP mg/L	DOP mg/L	$\delta^{15}N$ $^o/_{oo}$	NH_4 µM
9/26/2007 15:00	-77.0	1	9.40	0.75	8.65	36.40	1.80	N/A	N/A	N/A	10.04
9/26/2007 16:00	-77.0	4	1.30	0.13	1.17	4.30	0.35	0.56	0.21	4	1.59
9/26/2007 17:00	-201.8	5	0.83	0.11	0.72	2.70	0.19	0.60	0.41	N/A	0.94
9/26/2007 18:00	-222.6	6	0.73	0.11	0.62	1.70	0.11	0.38	0.27	6	0.74
9/26/2007 19:00	-224.9	7	0.79	0.08	0.71	1.00	0.06	0.32	0.26	N/A	0.60
9/26/2007 20:00	-167.5	8	0.58	0.08	0.50	0.54	0.02	0.28	0.26	8	0.61
9/26/2007 21:00	-22.1	9	0.61	0.11	0.50	0.60	0.01	1.14	1.13	N/A	0.60
9/26/2007 21:30	140.6	10	7.50	0.67	6.83	34.70	1.90	2.61	0.71	10	8.71
9/26/2007 22:00	193.1	11A	8.70	0.75	7.95	39.20	3.10	3.43	0.33	N/A	8.04
9/26/2007 22:00	193.1	11B	8.10	0.59	7.51	36.10	2.70	2.81	0.11	N/A	7.58
9/26/2007 22:00	193.1	11C	7.30	0.56	6.74	31.70	2.10	2.70	0.60	N/A	8.65
9/26/2007 22:30	275.2	12	8.10	0.93	7.17	36.10	2.70	2.98	0.28	12	7.95
9/26/2007 23:00	293.4	13	8.00	0.80	7.20	36.90	2.40	2.62	0.22	N/A	0.78
9/26/2007 23:30	262.6	14	8.70	0.59	8.11	29.10	1.80	2.50	0.70	14	8.49
9/27/2007 0:00	274.7	15	7.10	0.59	6.51	36.60	2.40	2.76	0.36	N/A	8.42
9/27/2007 0:00	274.7	15d	6.80	0.59	6.21	35.80	2.30	2.77	0.47	N/A	N/A
9/27/2007 0:30	279.3	17	5.50	0.27	5.23	24.90	1.40	2.11	0.71	17	6.69
9/27/2007 1:00	276.7	18	7.10	0.72	6.38	33.40	1.90	2.49	0.59	N/A	8.75
9/27/2007 1:30	257.8	19	7.10	0.68	6.42	33.47	1.80	2.63	0.83	19	9.44
9/27/2007 2:00	241.9	20	7.20	0.63	6.57	34.50	1.90	2.58	0.68	N/A	9.22
9/27/2007 2:30	224.8	21	7.00	0.59	6.41	34.60	1.90	2.99	1.09	21	11.08
9/27/2007 3:00	180.3	22	10.00	0.83	9.17	49.70	3.20	3.21	0.01	N/A	11.15
9/27/2007 4:00	68.7	23	10.30	0.84	9.46	52.90	2.90	3.82	0.92	N/A	11.19
9/27/2007 5:00	-179.3	24	0.92	0.00	0.92	0.81	0.23	0.26	0.03	24	1.54
9/27/2007 6:00	-219.7	25	1.10	0.00	1.10	0.09	0.09	0.17	0.08	N/A	0.76
9/27/2007 7:00	-234.4	26	0.95	0.00	0.95	0.00	0.05	0.16	0.11	26	0.57
9/27/2007 8:00	-227.4	27	0.82	0.00	0.82	0.00	0.03	0.19	0.16	N/A	0.86
9/27/2007 9:00	-155.6	28	0.50	0.00	0.50	0.61	0.07	0.14	0.07	N/A	0.47
9/27/2007 9:30	-50.6	29	0.23	0.00	0.23	0.00	0.04	0.18	0.14	29	0.48
9/27/2007 10:00	46.0	30A	7.80	0.54	7.26	36.70	1.20	2.64	1.44	N/A	11.03
9/27/2007 10:00	46.0	30B	7.40	0.42	6.98	34.30	1.30	2.70	1.40	N/A	10.92
9/27/2007 10:00	46.0	30C	8.40	0.64	7.76	37.10	1.50	2.61	1.11	N/A	10.93
9/27/2007 10:30	236.7	31	7.60	0.63	6.97	35.60	1.60	2.40	0.80	31	9.45
9/27/2007 11:00	278.9	32	6.00	0.48	5.52	27.90	1.20	2.24	1.04	N/A	9.33
9/27/2007 11:30	281.2	33	6.30	0.88	5.42	28.80	1.40	2.37	0.97	33	9.37
9/27/2007 12:00	281.5	34	6.20	0.55	5.65	27.60	1.20	1.97	0.77	N/A	7.55
9/27/2007 12:00	281.5	34d	6.30	0.57	5.73	28.00	1.20	2.05	0.85	N/A	7.41
9/27/2007 12:30	277.9	36	6.80	0.83	5.97	26.90	0.89	2.02	1.13	36	7.93
9/27/2007 13:00	287.6	37	6.00	0.72	5.28	26.10	0.96	2.03	1.07	N/A	6.43
9/27/2007 13:30	274.6	38	5.30	0.59	4.71	22.60	0.99	1.68	0.69	38	7.77
9/27/2007 14:00	248.7	39	5.60	0.72	4.88	23.60	0.95	1.78	0.83	N/A	4.29
9/27/2007 14:30	246.8	40	5.40	0.69	4.71	22.50	0.89	1.91	1.02	40	4.18
9/27/2007 15:00	202.6	41	6.10	0.72	5.38	23.60	1.00	2.13	1.13	N/A	4.01
9/27/2007 15:30	170.2	42	8.40	0.77	7.63	30.90	1.50	2.65	1.15	42	10.49

Appendix 2. Nutrient Results—September 2007 Sampling Intensive (continued).

Day-Hour (EDT)	Flow (m^3/s)	Sample No.	N+N µM	NO_2 µM	NO_3 µM	Si µM	P µM	TDP mg/L	DOP mg/L	$\delta^{15}N$ ‰	NH_4 µM
9/27/2007 16:30	-39.3	43	9.90	0.93	8.97	36.60	1.80	3.42	1.62	N/A	10.31
9/27/2007 17:30	-158.2	44	0.61	0.05	0.56	1.20	0.18	0.37	0.19	44	0.73
9/27/2007 18:30	-219.2	45	0.21	0.00	0.21	0.00	0.28	0.25	-0.03	N/A	0.40
9/27/2007 19:30	-236.9	46	0.42	0.08	0.34	0.86	0.12	0.32	0.20	46	0.48
9/27/2007 20:30	-201.6	47	0.68	0.11	0.57	1.50	0.15	0.38	0.23	N/A	0.64
9/27/2007 21:30	-99.0	48	0.43	0.08	0.35	0.63	0.08	0.39	0.31	48	0.48
9/27/2007 22:00	-27.1	49	0.66	0.11	0.55	1.30	0.21	0.39	0.18	N/A	0.64
9/27/2007 22:30	173.0	50	4.90	0.40	4.50	19.30	0.86	1.26	0.40	50	3.87
9/27/2007 23:00	231.4	51A	4.70	0.45	4.25	17.20	0.75	1.21	0.46	N/A	3.37
9/27/2007 23:00	231.4	51B	4.90	0.53	4.37	17.50	0.80	1.15	0.35	N/A	3.30
9/27/2007 23:00	231.4	51C	3.90	0.40	3.50	12.60	0.76	1.07	0.31	N/A	3.14
9/27/2007 23:30	240.9	52	3.10	0.27	2.83	8.60	0.54	1.02	0.48	52	2.28
9/28/2007 0:00	235.0	53	2.30	0.32	1.98	4.90	0.39	0.86	0.47	N/A	1.95
9/28/2007 0:00	235.0	53d	2.90	0.36	2.54	6.20	0.48	0.97	0.49	N/A	1.97
9/28/2007 0:30	249.4	55	3.20	0.39	2.81	11.60	0.49	0.92	0.43	55	2.54
9/28/2007 1:00	254.7	56	3.10	0.25	2.85	12.40	0.54	0.92	0.38	N/A	3.04
9/28/2007 1:30	269.3	57	3.40	0.41	2.99	17.20	0.51	0.97	0.46	57	3.40
9/28/2007 2:00	246.3	58	3.30	0.35	2.95	13.80	0.61	0.97	0.36	N/A	4.29
9/28/2007 2:30	239.1	59	5.20	0.53	4.67	20.20	0.83	1.32	0.49	59	4.93
9/28/2007 3:00	223.5	60	5.80	0.57	5.23	21.80	1.00	1.54	0.54	N/A	6.50
9/28/2007 3:30	192.2	61	7.50	0.64	6.86	26.80	1.40	1.81	0.41	61	7.05
9/28/2007 4:00	168.2	62	8.00	0.67	7.33	27.60	1.30	1.91	0.61	N/A	7.07
9/28/2007 5:00	-84.3	63	4.90	0.44	4.46	17.10	1.10	1.64	0.54	N/A	5.31
9/28/2007 6:00	-192.7	64	0.57	0.00	0.57	0.00	0.06	0.30	0.24	64	0.87
9/28/2007 7:00	-220.2	65	0.40	0.00	0.40	0.00	0.04	0.37	0.33	N/A	0.56
9/28/2007 8:00	-253.3	66	0.16	0.00	0.16	0.00	0.04	0.26	0.22	66	0.41
9/28/2007 9:00	-231.5	67	0.45	0.00	0.45	0.00	0.05	0.19	0.14	N/A	0.43
9/28/2007 10:00	-171.8	68	0.36	0.00	0.36	0.00	0.04	0.12	0.08	N/A	0.49
9/28/2007 10:30	-37.1	69	0.25	0.00	0.25	0.00	0.04	0.21	0.17	69	0.67
9/28/2007 11:00	166.5	70A	4.70	0.44	4.26	20.50	0.42	1.15	0.73	N/A	2.39
9/28/2007 11:00	166.5	70B	4.10	0.37	3.73	16.60	0.50	1.18	0.68	N/A	2.43
9/28/2007 11:00	166.5	70C	3.90	0.33	3.57	20.00	0.58	0.97	0.39	N/A	4.15
9/28/2007 11:30	201.0	71	1.30	0.11	1.19	8.00	0.24	0.50	0.26	71	1.29
9/28/2007 12:00	215.2	72	0.65	0.07	0.58	7.90	0.18	0.58	0.40	N/A	0.74
9/28/2007 12:00	215.2	72d	0.70	0.05	0.65	9.10	0.24	0.64	0.40	N/A	0.81
9/28/2007 12:30	245.1	74	0.35	0.00	0.35	5.70	0.15	0.39	0.24	74	0.64
9/28/2007 13:00	210.8	75	0.22	0.00	0.22	3.20	0.10	0.46	0.36	N/A	0.59
9/28/2007 13:30	192.4	76	0.34	0.00	0.34	4.80	0.11	0.49	0.38	76	0.60
9/28/2007 14:00	265.2	77	0.41	0.00	0.41	4.70	0.05	0.47	0.42	N/A	0.67
9/28/2007 14:30	252.5	78	0.42	0.01	0.41	6.10	0.10	0.49	0.39	78	0.77
9/28/2007 15:00	246.1	79	0.95	0.00	0.95	9.90	0.13	0.59	0.46	N/A	0.77
9/28/2007 15:30	235.1	80	2.80	0.14	2.66	15.40	0.33	0.96	0.63	80	1.92
9/28/2007 16:00	226.4	81	3.10	0.16	2.94	15.30	0.39	1.10	0.71	N/A	2.56
9/28/2007 16:30	176.4	82	3.20	0.24	2.96	16.00	0.40	1.24	0.84	N/A	2.09
9/28/2007 17:00	113.7	83	4.10	0.33	3.77	17.10	0.47	N/A	N/A	N/A	2.21

Appendix 3. Microbiological Results—June 2007 Sampling Intensive.

Microbiology results are shown in Tables 1a and 1b for the June 2007 sampling intensive. These represent two continuous sampling periods broken into time segments. Tables are colorized to reflect either the incoming (blue) or outgoing (yellow) tidal flow.

Table 1a: Microbial Water Quality of Incoming and Outgoing Tides—June 4, 2007

	Assay	6/4/2007 0030	0100	0230	0400	0500	0600	0800	1000	1200	1400	1600	1800	2000	2200
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	31	31	10	10	63	51	<10	<1	10	<10	10	10	10	<10
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	31	141	87	189	122	165	20	31	36	20	20	81	20	50
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	1495	6586	6488	8664	12997	8664	1725	110	7270	5475	7270	1199	4160	1396
	Presence of **Human-source Enterococci** by PCR (esp gene marker	nd	nd	nd	+	nd	nd	nd	-	nd	nd	-	nd	nd	-
	Presence of **Human-source Bacteroides** HF8 marker by PCR	nd	nd	nd	-	nd	nd	nd	-	nd	nd	-	nd	nd	-
	Presence of **Human-source Bacteroides** HuBac marker by PCR	nd	nd	nd	+	nd	nd	nd	-	nd	nd	-	nd	nd	-
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp**. (IpaB gene)	nd	nd	nd	-	nd	nd	nd	-	nd	nd	-	nd	nd	-
	E. coli O157:H7 (rfb gene)	nd	nd	nd	-	nd	nd	nd	-	nd	nd	-	nd	nd	-
	Campylobacter jejuni (HipO gene)	nd	nd	nd	-	nd	nd	nd	-	nd	nd	-	nd	nd	-
	Staphylococcus aureus (clfA gene)	nd	nd	nd	+	nd	nd	nd	-	nd	nd	-	nd	nd	-
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.3	nd	nd	<1
	Giardia cysts (per 100 L)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4.2	nd	nd	<1
Presence of Human viruses (by PCR)	**Human Adenovirus**	nd	nd	nd	+	nd	nd	nd	-	nd	nd	-	nd	nd	+
	Noroviruses	nd	nd	nd	+	nd	nd	nd	-	nd	nd	-	nd	nd	-
	Enteroviruses	nd	nd	nd	-	nd	nd	nd	-	nd	nd	-	nd	nd	-

(yellow) = outgoing tide
(blue) = incoming tide

nd = "not determined"

Appendix 3. Microbiological Results—June 2007 Sampling Intensive (continued).

Table 1b: Microbial Water Quality of Incoming and Outgoing Tides—June 5, 2007

	Assay	6/5/2007													6/6/2007
		0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2300	0000
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	**<10**	**10**	**20**	**10**	**<10**	**<10**	**<10**	**10** **10**	**10**	**10**	**<10**	**<10**	**<10**	**10** **<10**
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	**20**	**20**	**20**	**30**	**20**	**30**	**10**	**60** **30**	**30**	**82**	**86**	**30**	**61**	**30** **51**
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	**738**	**5475**	**6130**	**7701**	**2755**	**3255**	**1050**	**5475** **4106**	**6131**	**8664**	**3873**	**1046**	**663**	**987** **1014**
	Presence of **Human-source Enterococci** by PCR (esp gene marker	nd	nd	**+**	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**		nd
	Presence of **Human-source Bacteroides** HF8 marker by PCR	nd	nd	**+**	nd	nd		nd	nd		nd	nd			nd
	Presence of **Human-source Bacteroides** HuBac marker by PCR	nd	nd	**+**	nd	nd	**-**	nd	nd	**+**	nd	nd	**+**		nd
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp**. (IpaB gene)	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**		nd
	E. coli O157:H7 (rfb gene)	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**		nd
	Campylobacter jejuni (HipO gene)	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**		nd
	Staphylococcus aureus (clfA gene)	nd	nd	**+**	nd	nd	**-**	nd	nd	**-**	nd	nd	**-**		nd
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	nd	**2.4**	nd	nd	nd	nd	nd	nd	nd	nd	nd		nd
	Giardia cysts (per 100 L)	nd	nd	**1.2**	nd	nd	nd	nd	nd	nd	nd	nd	nd		nd
Presence of Human viruses (by PCR)	**Human Adenovirus**	nd	nd	**-**	nd	nd	**-**	nd	nd	**+**	nd	nd	**-**		nd
	Noroviruses	nd	nd	**-**	nd	nd	nd	nd	nd	nd	nd	nd	nd		nd
	Enteroviruses	nd	nd	**+**	nd	nd	nd	nd	nd	nd	nd	nd	nd		nd

Appendix 4. Microbiological Results—September 2007 Sampling Intensive.

The following data tables (Tables 1a-1f) summarize data elements common to both 48-hour sampling periods at Boynton Inlet. Two duplicate tables were created showing the two principal concentration units, mg/L and µM. Please note, however, that some data elements may be present in one sampling period and missing in the other. The term "ns" denotes not sampled, while the term "na" denotes not available. Phosphate measurements were obtained during the June 2007 sampling intensive but are not shown due to possible contamination of the samples. Total organic nitrogen was not included in the September 2007 tables because of a breakdown in the analytical system at Florida Atlantic University. Nitrogen isotope ratio analysis was performed only during the September 2007 sampling period.

Table 1a.   Microbial Water Quality of Incoming and Outgoing Tides on September 26, 2007 (1500-2330 hours)

		9/26/2007													
	Assay	1500	1600	1700	1800	1900	2000	2100	2130	2200-A	2200-B	2200-C	2230	2300	2330
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	**223**	**20**	**10**	**<10**	**<10**	**10**	**10**	**196**	**155**	**321**	**235**	**114**	**245**	**384**
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	**622**	**1727**	**1296**	**1842**	**459**	**60**	**439**	**618**	**1077**	**1243**	**1153**	**1212**	**397**	**805**
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	**24196**	**9804**	**3255**	**5794**	**3255**	**2142**	**3255**	**19863**	**>24196**	**19863**	**24196**	**15531**	**17329**	**15531**
	Presence of **Human-source Enterococci** by PCR (esp gene marker	-	-	-		-	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HF8 marker by PCR	-	-	-		-	-	-	-	-	-	-	+	-	-
	Presence of **Human-source Bacteroides** HuBac marker by PCR	-	-	-		-	-	-	-	+	+	+	+	+	+
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp**. (ipaB gene)	-	-	-		-	-	-	-	-	-	-	-	-	-
	E. coli O157:H7 (rfb gene)	-	-	-		-	-	-	-	-	-	-	-	-	-
	Campylobacter jejuni (HipO gene)	-	-	-		-	-	-	-	-	-	-	-	-	-
	Staphylococcus aureus (clfA gene)	-	-	-		-	-	-	-	-	-	-	-	-	-
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	**<1**	nd		nd	nd	nd	nd	nd	**2.6**	nd	nd	nd	nd
	Giardia cysts (per 100 L)	nd	**<1**	nd		nd	nd	nd	nd	nd	**5.4**	nd	nd	nd	nd
Presence of Human viruses (by PCR)	**Human Adenovirus**	-	-	nd		nd	-	-	+	+	+	+	-	-	-
	Noroviruses	nd	-	nd		nd	-	nd	-	nd	-	nd	nd	nd	nd
	Enteroviruses	nd	-	nd		nd	-	nd	+	nd	-	nd	nd	nd	nd

= outgoing tide
= incoming tide

nd = "not determined"
*value exceeds EPA regulatory limit of 105 MPN/100 mL

Appendix 4. Microbiological Results—September 2007 Sampling Intensive (continued).

Table 1b. Microbial Water Quality of Incoming and Outgoing Tides on September 27, 2007 (0000-0930 hours)

	Assay	9/27/2007													
		0000	0030	0100	0130	0200	0230	0300	0400	0500	0600	0700	0800	0900	0930
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	335 163	95	103	166	95	84	152	126	41	<10	41	41	<10	10
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	724 414	645	537	425	417	362	474	320	324	497	185	86	94	71
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	19863 >24196	14136	>24196	24196	14136	12033	15531	12997	3654	3130	1670	1012	1396	2098
	Presence of **Human-source Enterococci** by PCR (esp gene marker	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HF8 marker by PCR	-	-	-	-	+	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HuBac marker by PCR	+	-	-	-	+	-	+	+	-	-	-	-	-	+
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp**. (IpaB gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E. coli O157:H7 (rfb gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Campylobacter jejuni (HipO gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Staphylococcus aureus (clfA gene)	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	nd	nd	nd	nd	nd	nd	nd	<1	nd	nd	nd	nd	nd
	Giardia cysts (per 100 L)	nd	nd	nd	nd	nd	nd	nd	nd	<1	nd	nd	nd	nd	nd
Presence of Human viruses (by PCR)	**Human Adenovirus**	-	-	-	-	+	+	-	+	-	nd	-	-	-	-
	Noroviruses	-	nd	nd	nd	nd	nd	-	nd	-	nd	nd	-	nd	+
	Enteroviruses	-	nd	nd	nd	nd	nd	+	nd	-	nd	nd	-	nd	-

Appendix 4. Microbiological Results—September 2007 Sampling Intensive (continued).

Table 1c. Microbial Water Quality of Incoming and Outgoing Tides on September 27, 2007 (1000-1530 hours)

		9/27/2007													
	Assay	1000-A	1000-B	1000-C	1030	1100	1130	1200	1230	1300	1330	1400	1430	1500	1530
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	**101**	**71**	**183**	**152**	**134**	**176**	**254** **280**	**237**	**246**	**183**	**152**	**266**	**141**	**138**
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	**259**	**207**	**153**	**363**	**512**	**364**	**780** **866**	**573**	**633**	**958**	**395**	**651**	**312**	**337**
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	**1199**	**15531**	**10462**	**6586**	**8164**	**10432**	**15531** **12997**	**3151**	**3151**	**15531**	**12997**	**7701**	**8164**	**9804**
	Presence of **Human-source Enterococci** by PCR (esp gene marker	-	-	-	-	-	-		-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HF8 marker by PCR	-	-	-	-	-	-		-	-	-	-	-	-	+
	Presence of **Human-source Bacteroides** HuBac marker by PCR	+	+	+	-	-	-		-	-	+	-	+		+
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp**. (IpaB gene)	-	-	-	-	-	-		-	-	-	-	-	-	-
	E. coli O157:H7 (rfb gene)	-	-	-	-	-	-		-	-	-	-	-	-	-
	Campylobacter jejuni (HipO gene)	-	-	-	-	-	-		-	-	-	-	-	-	-
	Staphylococcus aureus (clfA gene)	-	-	-	-	-	-		-	-	-	-	-	-	-
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	**1.2**	nd	nd	nd	d		nd	nd	nd	nd	nd	nd	nd
	Giardia cysts (per 100 L)	nd	**<1**	nd	nd	nd	d		nd	nd	nd	nd	nd	nd	nd
Presence of Human viruses (by PCR)	**Human Adenovirus**	+	+	-	-	-	-		-	-	-	-	-	-	+
	Noroviruses	nd	-	nd	nd	nd	d		-	nd	nd	nd	nd	nd	-
	Enteroviruses	nd	-	nd	nd	nd	d		-	nd	nd	nd	nd	nd	-

Appendix 4. Microbiological Results—September 2007 Sampling Intensive (continued).

Table 1d. Microbial Water Quality of Incoming and Outgoing Tides on September 27-28, 2007 (1630-0030 hours)

		9/27/2007												9/28/2007	
	Assay	1630	1730	1830	1930	2030	2130	2200	2230	2300-A	2300-B	2300-C	2330	0000	0030
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	**120**	**52**	**<10**	**10**	**41**	**10**	**<10**	**41**	**20**	**31**	**41**	**51**	**20** **10**	**20**
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	**363**	**333**	**206**	**324**	**166**	**1057**	**976**	**560**	**474**	**747**	**1050**	**496**	**375** **260**	**604**
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	**12033**	**5172**	**2098**	**2613**	**2595**	**5172**	**7270**	**11199**	**9208**	**12997**	**9804**	**8664**	**11199** **10462**	**12033**
	Presence of **Human-source Enterococci** by PCR (esp gene marker	-	-	-	-	-	-	-	-	+	-	-	-	-	-
	Presence of **Human-source Bacteroides** HF8 marker by PCR	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HuBac marker by PCR	-	-	-	-	-	-	+	+	+	-	-	+	-	-
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp.** (IpaB gene)	-	-	-	-	-	-	+	-	-	-	-	-	-	-
	E. coli O157:H7 (rfb gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Campylobacter jejuni (HipO gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Staphylococcus aureus (clfA gene)	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	**<1**	nd	nd	nd	nd	nd	nd	**<1**	nd	nd	nd	nd	nd
	Giardia cysts (per 100 L)	nd	**<1**	nd	nd	nd	nd	nd	nd	**15.2**	nd	nd	nd	nd	nd
Presence of Human viruses (by PCR)	**Human Adenovirus**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noroviruses	nd	-	nd	nd	-	nd	+	nd	+	nd	nd	nd	nd	nd
	Enteroviruses	nd	-	nd	nd	-	nd	-	nd	+	nd	nd	nd	nd	nd

Appendix 4. Microbiological Results—September 2007 Sampling Intensive (continued).

Table 1e. Microbial Water Quality of Incoming and Outgoing Tides on September 28, 2007 (0100-1030 hours)

		9/28/2007													
	Assay	0100	0130	0200	0230	0300	0330	0400	0500	0600	0700	0800	0900	1000	1030
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	**50**	**51**	**155**	**156**	**256**	**250**	**474**	**95**	**10**	**20**	**30**	**<10**	**<10**	**20** **10**
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	**465**	**491**	**1077**	**1254**	**3026**	**3578**	**3088**	**896**	**893**	**705**	**474**	**350**	**325**	**2381** **7270**
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	**12997**	**15531**	**11199**	**14136**	**15531**	**17329**	**15531**	**10462**	**5172**	**7270**	**24196**	**4352**	**4106**	**9208** **9804**
	Presence of **Human-source Enterococci** by PCR (esp gene marker	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HF8 marker by PCR	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HuBac marker by PCR	-	-	+	+	-	-	-	-	-	-	-	-	-	-
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp**. (ipaB gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E. coli O157:H7 (rfb gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Campylobacter jejuni (HipO gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Staphylococcus aureus (clfA gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	nd	nd	nd	nd	nd	nd	nd	**<1**	nd	nd	nd	nd	nd
	Giardia cysts (per 100 L)	nd	nd	nd	nd	nd	nd	nd	nd	**<1**	nd	nd	nd	nd	nd
Presence of Human viruses (by PCR)	**Human Adenovirus**	+	+	-	-	-	-	-	-	-	-	-	-	-	+
	Noroviruses	-	nd	nd	nd	nd	nd	-	nd	-	nd	nd	-	nd	+
	Enteroviruses	-	nd	nd	nd	nd	nd	-	nd	-	nd	nd	-	nd	+

Appendix 4. Microbiological Results—September 2007 Sampling Intensive (continued).

Table 1f. Microbial Water Quality of Incoming and Outgoing Tides on September 28, 2007 (1100-1700 hours)

	Assay	9/28/2007														
		1100-A	1100-B	1100-C	1130	1200	1230	1300	1330	1400	1430	1500	1530	1600	1630	1700
Fecal Indicator Bacteria	**viable enterococci** by IDEXX EnteroLert, MPN/100 mL	**10**	**10**	**40**	**30**	**31** **20**	**41**	**41**	**10**	**20**	**20** **20**	**10**	**20**	**20**	**10**	**10** **< 10**
	viable E. coli by IDEXX EnteroLert, MPN/100 mL	**4160**	**1495**	**2427**	**2700**	**2589** **1638**	**1368**	**1024**	**3044**	**1609**	**1279** **675**	**981**	**935**	**367**	**390**	**211** **<10**
	viable Total Coliforms by IDEXX EnteroLert, MPN/100 mL	**8297**	**5247**	**10462**	**10462**	**11199** **9208**	**5012**	**14136**	**10462**	**12033**	**3538** **14136**	**12033**	**14136**	**9804**	**12033**	**1701** **<10**
	Presence of **Human-source Enterococci** by PCR (esp gene marker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HF8 marker by PCR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Presence of **Human-source Bacteroides** HuBac marker by PCR	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-
Presence of Pathogenic Bacteria (by PCR)	**Salmonella sp**. (ipaB gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E. coli O157:H7 (rfb gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Campylobacter jejuni (HipO gene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Staphylococcus aureus (clfA gene)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Pathogenic Protozoans (by IMS/IMF)	**Cryptosporidium oocysts** (per 100 L)	nd	**<1**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Giardia cysts (per 100 L)	nd	**<1**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Presence of Human viruses (by PCR)	**Human Adenovirus**	+	+	+	-	+	+	-	-	-	+	+	-	-	-	-
	Noroviruses	nd	+	nd	nd	nd	nd	nd	nd	nd	-	nd	-	-	nd	-
	Enteroviruses	nd	+	nd	nd	nd	nd	nd	nd	nd	-	nd	-	-	nd	-

Appendix 5. FAU data for the June 2007 Intensive (page 1).

Date EDT	Time EDT	Flow m^3/s	pH	F*	TDS mg/L	F	Sal ppt	F	DO mg/L O_2	Turb. NTU	TOC mg/L C	F	TN mg/L N	F	TON mg/L	TSS mg/L	*E. Coli* MPN/ 100 mL	F	Total Col. MPN/ 100 mL	F	Entero MPN/ 100 mL	F
4-Jun	0:30	142.0	8.44		30.12		30.2		5.02	1.39	2.74		0.54		0.47	5.0	31	Q	1495	Q,q	31	Q,q
4-Jun	1:00	176.4	8.58		28.04		27.8		5.21	1.85	3.79		0.02	U	-0.05	4.6	141	Q	6586	Q,q	31	Q,q
4-Jun	2:30	183.8	8.72		31.43		31.5		4.77	0.71	2.60		0.26		0.20	5.9	87		6488	q	10	q
4-Jun	3:00	185.4	8.65		31.74		31.9		4.77	1.39	1.96		0.23		0.17	3.7						
4-Jun	4:00	173.1	8.68		28.68		28.5		5.50	1.71	3.08		0.37		0.28	5.0	189		8664	q	10	q
4-Jun	4:00	173.1									3.21		0.42		0.42							
4-Jun	5:00	135.7	8.66		28.58		28.3		4.87	2.03	3.06		0.37		0.26	4.5	122		12997		63	
4-Jun	5:55	64.4	8.27		23.70		23.0		5.28	1.74	4.53		0.48		0.36	4.7	165		8664		51	
4-Jun	7:00	-106.3	8.68		34.79		35.3		4.60		1.50		0.21		0.19	2.8						
4-Jun	8:00	-152.3	8.68		35.47		36.9		4.68	0.20	0.88	U	0.13		0.12	3.3	20		1725		<10	
4-Jun	9:01	-163.3	8.85		35.09		35.7		4.64		1.20		0.27		0.25	2.7						
4-Jun	10:00	-148.3	8.77		35.39		36.1		4.62	0.04	0.68	U	0.09		0.08	2.3	31		110		<10	
4-Jun	11:10	-95.7	9.24		34.94		35.5		4.47		0.64	U	0.09		0.08	2.3						
4-Jun	12:00	66.4	8.90		26.75		26.3		4.29	1.62	2.36		0.26		0.19	3.8	36		7270		10	
4-Jun	12:00	66.4															36		7270		10	
4-Jun	13:00	155.3	8.96		31.21		31.2		4.31		2.09		0.25		0.22	3.7						
4-Jun	13:00	155.3									3.31		0.38									
4-Jun	14:00	168.8	8.97		30.75		30.7		4.28	1.21	2.34		0.27		0.24	3.9	20		5475		<10	
4-Jun	15:00	160.1	8.96		30.34		30.2		4.16		2.63		0.27		0.25	3.6						
4-Jun	16:00	150.2	9.09		30.38		30.3		4.20	1.00	2.60		0.33		0.28	3.6	20		7270		10	
4-Jun	17:00	106.2	8.62		29.71		29.5		4.27	1.12	2.64		0.32		0.27	10.3						
4-Jun	18:00	-15.8	8.72		29.08		28.8		4.27	2.08	1.51	J3i	0.20	J3i	0.14	11.4	81		11199		10	
4-Jun	19:00	-127.2	8.85		35.91		36.6		4.29	0.30	0.62	U, J3i	0.12	J3i	0.11	5.7						
4-Jun	20:00	-177.1	8.08		26.13		25.6		4.77	0.15	0.16	U, J3i	0.09	J3i	0.07	4.3	20		4160		10	
4-Jun	21:00	-186.4	7.43	a	nr	a	36.2	a	4.78	0.17	0.14	U, J3i	0.08	J3i	0.07	5.3						
4-Jun	22:05	-182.8	8.17	a	nr	a	36.3	a	4.81	0.00	-0.08	U, J3i	0.09	J3i	0.08	4.5	50		1396		<10	
4-Jun	23:00	-169.7	7.81	a	nr	a	36.2		4.84		0.18	U, J3i	0.10	J3i	0.09	4.4						
4-Jun	23:00	-169.7									0.02	U, J3i	0.10	J3i								
5-Jun	0:00	-89.4	7.86	a	nr	a	36.3		4.88	0.07	-0.10	U, J3i	0.09	J3i	0.08	8.3	20		738		<10	
5-Jun	1:00	134.1	7.81	a	nr	a	28.7		5.00		1.06	J3i	0.18	J3i	0.12	13.9						
5-Jun	2:00	201.4	7.85	a	nr	a	32.7		4.95	0.65	1.07	J3i	0.18	J3i	0.16	4.8	20		5475		10	
5-Jun	2:00	201.4									0.68	U, J3i	0.13	J3i	0.10							
5-Jun	3:00	190.3	7.76	a	nr	a	32.0		4.88		0.79	U, J3i	0.15	J3i	0.11	9.5						
5-Jun	4:00	188.3	7.88	a	nr	a	30.5		4.90	1.03	1.68	J3i	0.22	J3i	0.18	8.7	20		6131		20	
5-Jun	5:00	157.5	7.79	a	nr	a	29.6		4.94		1.82	J3i	0.25	J3i	0.19	6.0						
5-Jun	5:30	144.3	7.81	a	nr	a	nr	a	4.95		2.20	J3i	0.31	J3i	0.24							
5-Jun	6:00	117.5	7.79	a	nr	a	29.0		5.02	1.58	1.35	J3i	0.21	J3i	0.15	8.8	30	Q	7701	Q	10	Q

***F refers to "Flags," described at the bottom of the next page.**

Appendix 5. FAU data for the June 2007 Intensive (page 2).

Date EDT	Time EDT	Flow m^3/s	pH	F	TDS mg/L	F	Sal ppt	F	DO mg/L O_2	Turb. NTU	TOC mg/L C	F	TN mg/L N	F	TON mg/L	TSS mg/L	*E. Coli* MPN/ 100 mL	F	Total Col. MPN/ 100 mL	F	Entero MPN/ 100 mL	F
5-Jun	7:00	-27.6	7.75	a	nr	a	24.4		5.14		3.94	J3i	0.45	J3i	0.38	3.4						
5-Jun	8:00	-122.5	7.85	a	nr	a	36.4		4.81	0.17	1.72	J3i	0.17	J3i	0.15	6.7	20		2755		<10	
5-Jun	9:00	-165.3	8.00	a	nr	a	36.4		4.86		2.55	J3i	0.17	J3i	0.16	6.3						
5-Jun	10:00	-173.4	8.00	a	nr	a	36.3		4.81	0.24	0.17	U, J3i	0.09	J3i	0.08	4.7	30		3255		<10	
5-Jun	10:00	-173.4		a	nr	a										0.0	<10		0		<10	
5-Jun	11:00	-150.8	7.97	a	nr	a	36.4		4.73		0.39	U, J3i	0.07		0.06	5.2						
5-Jun	12:00	-90.1	7.96		35.79		36.4		4.45	0.35	0.25	U, J3i	0.05		0.03	4.6	10	Q	1050	Q	<10	Q
5-Jun	13:00	68.5	7.99		28.16		27.8		4.15		3.89		0.24		0.22	8.3						
5-Jun	14:00	150.0	7.72		32.06		32.2		4.28		1.83		0.14		0.13	7.8	60		5475		10	
5-Jun	14:00	150.0								0.75							30		4106		10	
5-Jun	15:00	161.5	7.76		31.48		31.5		4.46		2.49		0.16		0.14	11.4						
5-Jun	16:00	154.5	7.71		30.17		30.1		4.44	1.70	2.91		0.15		0.14	7.6	30		6131		10	
5-Jun	16:00	154.5								1.56											10	
5-Jun	17:00	130.8	7.69		28.96		28.7		4.52		2.88		0.23		0.21	9.4						
5-Jun	17:50	114.4	7.68		28.60		28.3		4.52	2.27	4.46		0.14		0.12	10.1	82		8664		10	
5-Jun	19:00	-51.5	7.65		27.34		27.0		4.85		3.89		0.17		0.13	14.1						
5-Jun	20:00	-125.5	7.65		34.99		35.5		4.75	0.41	2.69		0.23		0.20	13.0	86		3873		<10	
5-Jun	21:00	-170.5	7.65		34.32		34.8		4.83		3.88		0.08		0.05	5.8						
5-Jun	21:00	-170.5									1.55		0.20									
5-Jun	22:00	-191.2	7.60		34.35		35.0		4.91	0.22	3.43		0.14		0.12	9.2	30		1046		<10	
5-Jun	23:00	-194.9	7.57		34.92		35.5		4.79	0.24	2.87		0.10		0.08	6.8	61		663		<10	
6-Jun	0:00	-157.5	7.50		35.03		35.1		4.80	0.41	2.10		0.09		0.06	11.6	30		987		10	
6-Jun	0:00	-157.5									1.57		0.09		0.07		51		1014		<10	

Flags

Q—Samples have passed the holding time.
q—Samples have passed the reading time (i.e., for bacteria: 24-28 hrs).
Y—Sample bottle broke and unpreserved sample used.
J3—Duplicate did not meet the 20% deviation criteria.
J3i—Calcheck did not meet the 15% deviation criteria.
K—Off scale low (estimated value because one or more bacteriological samples below detection limit).
U—Below detectable level.
I—Estimated data.
g—Samples were diluted and re-run.

d—Syringe malfunction, some air injected.
or—Out of range.
H—Sample was filtered, reported value corresponds with DOC-dissolved organic carbon.
O—Sampled, but analysis lost or not performed (i.e., sample was analyzed without reagent, test failed).
J4—Sample incubated at lower temperature (35°C).
L—Off scale high.
pc—Possible contamination.
a—Calibration error in field required re-analysis of the samples in the lab at room temperature.
nr—No reading.

1—Swapnil had 4/6 for *E. coli* = 104.
2—Swapnil had 2/2 for *E. coli* = 104.
3—TSS filter possible contamination.
4—Swapnil had 1/9 for *E. coli* = 101.
5—Tried both w/same pipette; Swapnil had ¼ *E. coli* = 50.
6—Operator noted 2/2 Entero but Swapnil had 3/2 ½ -hr later; Eco.
7—TSS filter possible contamination.
8—Different pipettes.
9—Duplicate done with same pipette for *E. coli* and Entero.

Appendix 6. Florida Atlantic University Results—September 2007 Sampling Intensive.

Sample id	ID	Lat	Lon	DecDay (EDT) (26sep=269)	Time (EDT)[1]	Flow m^3/sec	pH	TDS mg/L	Turbidity NTU	Salinity ppt	DO mg/L O_2	Air Temp °C	Water Temp °C	TOC mg/L C	TN mg/L N	NH4 mg/L N	NO3 mg/L N	P mg/L P	Total coliform MPN/ 100mL	E Coli MPN/ 100mL	Entero coccus MPN/ 100mL	Note
Inlet N	N	26.55461	-80.04764	269.39236	9:25	134.5	7.73	44.58	0.32	31.80				0.985	U	0.160	U	U	1,160	294	<10	1
060512A1	A1	26.44219	-80.04783	269.39375	9:27	134.5	8.01	44.53	1.42	31.87	4.35		25.7	0.968	U	0.690	U	0.029	30	30	<10	2
060512A2	A2	26.44219	-80.04783	269.39583	9:30	189.3	7.67	44.84	0	31.80				0.936	U	0.250	U	0.041	52	10	<10	
Inlet S	S	26.55161	-80.04986	269.40278	9:40	189.3	7.81	44.74	0.53	32.03				0.922	U	0.120	U	U	10,462	1,274	<10	
060512A3	A3	26.44219	-80.04783	269.40278	9:40	189.3	7.86	44.66	0	31.74				1.075	U	0.440	U	0.034	631	309	<10	
060512B1	B1	26.35869	-80.03333	269.42708	10:15	249.0	7.88	44.27	0.15	31.78	4.29	24	25.8	0.985	U	0.220	U	0.031	52	20	<10	3
060512B2	B2	26.35869	-80.03333	269.43056	10:20	249.0	7.72	44.60	0	31.98				0.926	U	0.240	U	U	389	160	<10	
060512B3	B3	26.35869	-80.03333	269.43403	10:25	249.0	7.66	45.63	0	31.86				0.947	U	0.210	U	0.029	703	388	<10	
060512C1	C1	26.54747	-80.04003	269.46181	11:05	249.0	7.90	44.04	0.07	32.00	4.48		25.36	1.005	U	0.310	U	0.032	865	437	<10	
060512D1	D1	26.54008	-80.04061	269.48958	11:45	234.0	7.95	44.74	0	30.32	4.44	24	25.4	1.030	U	0.220	U	U	389	243	<10	
060512E1	E1	26.53500	-80.03961	269.49606	*11:54*	234.0	7.91	44.33	0	31.75	4.34	25	25.82	1.114	U	0.230	U	U	4,352	737	<10	
060512F1	F1	26.54469	-80.04144	269.50255	*12:03*	241.1	7.89	43.23	0.42	31.48	4.27	25	26.1	1.276	U	0.230	U	0.036	5,475	1,471	<10	
060512G1	G1	26.54558	-80.04453	269.50903	12:13	241.1	7.87	44.12	0.27	31.46	4.16	25	26.38	1.235	U	0.200	U	0.050	5,794	878	10	
060512H1	H1	26.54614	-80.04772	269.51458	12:21	238.4	7.82	44.11	0.17	31.41	4.16	26	26.51	1.316	U	0.890	U	U	5,794	652	<10	
060512J1	J1	26.54286	-80.05144	269.52292	12:33	234.4	7.89	44.40	0	31.60	4.25	25	26.05	1.131	U	0.240	U	U	6,488	746	10	4
060512H2	H2	26.54614	-80.04772	269.52500	*12:36*	234.4	7.84	44.09	0.15	31.42	4.14	26	26.54	1.388	U	0.630	U	0.039	5,475	519	<10	
060512K1	K1	26.54261	-80.04808	269.52847	12:41	234.4	7.89	44.07	0.07	30.92	4.29	26	25.93	1.387	U	0.210	U	U	7,701	1,578	<10	
060512I1	I1	26.54981	-80.05050	269.53542	12:51	240.5	7.83	44.02	0.82	31.35	3.94	26	27.33	1.625	U	0.530	U	U	2,064	935	<10	
060512L1	L1	26.55956	-80.04897	269.54167	13:00	240.5	7.89	43.89	0.82	31.17	3.72	27	28.22	1.737	U	0.190	U	0.079	7,270	1,178	20	
060522A1	A1	26.54419	-80.04308	269.54514	13:05	229.4	8.16	44.17	0.60		3.55	29.5	28.8	1.106	U	U	0.027	4.970	1,503	574	10	5
060522B1	B1	26.54142	-80.04364	269.55417	13:18	225.6	7.88	45.09	0.61		3.39	29.5	29.5	1.124	U	U	0.044	U	2,909	626	<10	
060522B2	B2	26.54142	-80.04364	269.55833	13:24	225.6	7.88	44.74	1.42		3.37	29.9	29.6			0.110	0.045	0.210	4,611	916	10	6
060522C1	C1	26.54611	-80.04181	269.57778	13:52	194.9	7.87	44.24	0.56		3.49	30.6	29.1	1.249	U	U	0.039	U	3,282	696	<10	
060522D1	D1	26.54728	-80.04172	269.58056	13:56	194.9	7.95	44.29	0.60		3.33	32.4	29.7	1.247	U	U	U	U	3,873	698	<10	
060512TB	TB													0.300	U				<10	<10	<10	

NOTES

U - below detection limit

TB - blank

1 - italized times were interpolated

2 - birds and 3 swimmers

3 - Open ocean, 57 ft depth

4 - 55 ft depth, flying fish

5 - Construction on the corner of the canal finger

6 - About 8 people on the site

7 - People at north